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INVESTIGATION OF SPRINGING RESPONSES ON THE GREAT LAKES ORE CARRIER M/V STEWART J. CORT

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16. Abstract

From October through December 1979, DTNSRDC collected wave, stress and pressure measurements from on board the 1000 foot ore carrier, M/V STEWART J. CORT. An attempt was also made to verify the wave measurement system on the CORT via correlation with data from a wave buoy deployed by USCG helicopter. Following the data collection period, DTNSRDC performed a preliminary data analysis and made comparisons between measured and analytical bending moment RAO's (response amplitude operators). The main text of this report includes a complete description of the full scale instrumentation, calibration, data analysis and results.

Included as additional appendices are descriptions of the procedures used to develop the analytical RAO's used by DTNSRDC for comparison with the measured RAO's.

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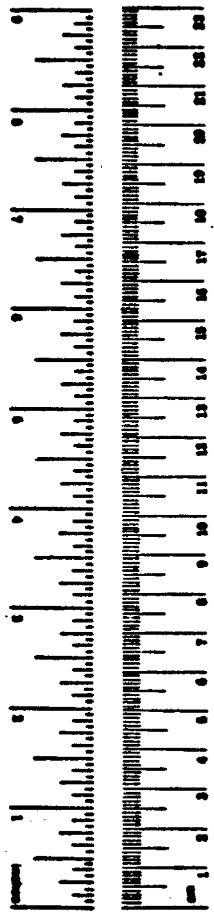
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

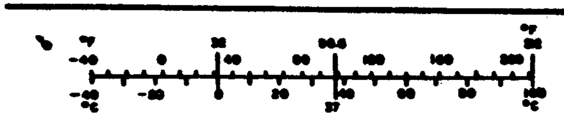
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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ABSTRACT

Stress, wave, pressure and motion data were collected on a 1,000 ft Great Lakes Ore Carrier, the M/V STEWART J. CORT, from mid October through mid December 1979. Response Amplitude Operators (RAO's) calculated from the data show the springing response of such ships to be sensitive to ship speed, draft and wave to ship angle of encounter. Comparisons of measured RAO's from the collected data with analytical RAO's calculated by the American Bureau of Shipping (ABS) and Webb Institute of Naval Architecture (WEBB) show the ABS springing model to give good estimates of the ship midship bending response, while the WEBB springing model tends to over-estimate the ship bending moment response. A method for predicting the combined wave induced and springing bending stresses, based on the statistical properties of the midship bending stress response spectrum, gives a generally conservative estimate of the maximum single amplitude midship bending stress. The combined lateral and vertical bending stresses for bow sea headings examined is seen to produce a maximum deck edge stress which averages 8 percent higher than the maximum vertical bending stress. Torsional stresses were found to be negligible for the head and bow sea cases this project concentrated on. Comparison of the on board wave measuring system system with wave rider buoys and visual estimates of wave height indicates the on board system (a Collins radar altimeter) to be an acceptable method of wave measurement. Further validation tests are required.

ADMINISTRATIVE INFORMATION

The work described herein was performed by the Ship Structures Division of the Structures Department at the David W. Taylor Naval Ship R&D Center (DTNSRDC). The wave and stress measurements and analysis of springing response was performed under funds provided by the U.S. Coast Guard Guard MIPR-Z-70099-8-85117-5B. This work was performed at DTNSRDC under work unit 1730-603. The ship motion and pressure measurements were performed under funds provided by the Ship Structure Committee MIPR-Z70099-0-02259 and Project Order No. N6519779PO90714. This work was performed by DTNSRDC under work units 1730-400 and 1730-613.

INTRODUCTION

This report summarizes the data collected on board the Great Lakes Ore Carrier M/V STEWART J. CORT during the 1979 fall shipping season and presents the results of the data analyses in an attempt to develop a better understanding of springing induced stresses. Data collected includes wave, stress, motion and pressure responses from transducers located throughout the ship. Data was collected from mid October through mid December 1979 as the CORT made round trip transits between Burns Harbor, Indiana and Burlington Ore Docks-Superior, Wisconsin, via Lakes Michigan and Superior. In all, data was collected during seven round trips.

Primary emphasis in this report is placed on the analysis of wave and stress data recorded during the data collection period to:

(1) Determine how springing and wave induced stresses combine and

(2) Evaluate the validity of existing analytical springing models.

Data runs were 25 minutes in duration with most data taken during periods when the ship was encountering head or bow seas. All analyses reported herein will be concerned with these runs. Pressure data from 15 pressure transducers located in the CORT's forward quarter were also recorded. A preliminary analysis of this data was also performed and presented.

The bulk of the data analysis, however, centered on the examination of the midship vertical bending stresses and measured wave heights to calculate Response Amplitude Operators (RAO's) to help develop a better understanding of springing. Comparisons are made between calculated RAO's from the data collected and analytically generated RAO's for the same ship conditions. The relationship between springing and wave induced stresses and how these stresses combine to produce a maximum is examined in the frequency domain. Measurements were also made of midship lateral bending and torsional stresses since measurements concentrated

on head and bow sea cases. The magnitudes of the torsional stresses recorded were much smaller than the midship vertical bending stresses. Magnitudes of torsional stresses were very small (less than 200 psi) and are reported herein. Lateral bending stresses were combined with the midship vertical bending stress in the time domain to determine the peak deck edge stresses recorded during certain runs.

Comparisons are also made between the shipboard wave measuring system and wave rider buoys launched in the near proximity of the ship. Two systems were employed on board the CORT to measure wave heights during these trials. The first, a Collins Radar Altimeter was mounted on the ships bow and the second, a microwave radar previously used on the SEA-LAND MCLEAN (SL-7) evaluation (ref 1) was mounted on the CORT pilot house top. Both systems were configured and installed by the Naval Research Laboratory (NRL). The NRL system was performing unreliably and ceased functioning during the trials period. All wave measurements reported herein are based on the Collins Radar Altimeter.

DATA COLLECTION

A complete list of measurements made on the CORT during the Fall 1979 trials is listed in Table 1 and the locations of these measurands are given in Figures 1 through 3. The data acquisition system (DAS) equipment locations for these transducers are given in Figure 2. Calibrations of transducers were performed at DTNSRDC, where applicable, and shipboard regularly as part of the data collection process. A description of calibrations performed and transducer sensitivities is given in Appendix A.

All data collected was stored digitally on magnetic tape using data acquisition software developed by DTNSRDC. A PDP 11/03 computer was used to control the collection and storage of the digitized data on magnetic tape. A

description of the data format used in storing the data on tape is given in Appendix B. The data for each run was stored on magnetic tape in the form of analog to digital (A/D) computer counts. All data analyses are computed using the A/D counts and converted to engineering units (EU) after computations are completed by multiplying the value computed in A/D counts by the Computer System Sensitivity, which is the A/D computer counts to EU conversion factor. Sensitivities for all data channels to convert from computer counts to engineering units can be found in Appendix A.

A listing of ship conditions (draft, speed, heading, location), and sea and wind conditions at the start of each data run are contained in header logs which were stored on magnetic tape as part of the data for each run. A listing of the header logs for all data runs conducted during the fall trials season is given in Appendix C. Appendix C also briefly explains the entries into the header logs and how each entry was determined.

All measurands were recorded during each data run made with the following exceptions. Wave information from the wave rider buoy was collected only on the runs designated as "buoy runs." These "buoy runs" were accomplished only when the buoys were deployed from CORT by a U.S. Coast Guard helicopter. The helicopters were stationed at the Traverse City, Michigan and Chicago, Illinois USCGAS and would rendezvous with CORT as conditions permitted. The buoys would be picked up from the CORT's deck by the helicopter, deployed 3 miles forward of the CORT's course, data were collected as the CORT approached and past the buoy, and the buoy would be retrieved by the same helicopter and returned to the CORT deck. In all only two such runs were completed. The NRL micro-wave radar ceased functioning for the last two round trips and no NRL wave data is available for runs 91 through 119. Additionally, the NRL radar consistently had long periods of drop out

(no signal) during most data runs and for the data runs with little or no drop out, the calculated wave heights from the NRL signal were far in excess of visual estimates of the existing waves. The Collins Radar altimeter also exhibited occasional drop outs but of much shorter duration and less frequently than did the NRL. The Collins Radar drop outs were compensated for in the software by linearly connecting the last valid data point before a drop out (of less than 2 seconds) with the next valid data point after a drop out, interpolating for the missing data, and then performing the wave height analysis. Runs with drop outs of more than 2 seconds were not included in the data analysis. For this reason, only the wave heights arrived at using the Collins radar were employed for data analysis. Pressure gages six and fourteen became unreliable during the data collection season, even though both gages performed according to manufacturers specifications during laboratory calibrations and upon installation in August of 1979. Gage fourteen became unbalanceable shortly after the data collection season began. Bridge resistance values were checked for the gage and found to be out of the typical range of resistances specified for these gages, indicating internal gage damage. All wiring was checked from the instrumentation to the gage and found to be in good condition. Pressure gage six was balanceable and gave the expected bridge output when shunted with a calibration resistor. However, this gage exhibited occasional voltage jumps in excess of those gages positioned in the near proximity of this gage. All cabling and connections were checked and found to be good. Different sets of signal conditioners were also used with this gage, with the same voltage jumps exhibited. The gage should be considered unreliable for data analysis purposes. Replacement of these gages as trials progressed was deemed unfeasible since gage replacement would require the use of divers. The reliability of the bottom bending gage became questionable as data analysis progressed and is discussed in Appendix A.

DATA ANALYSIS AND PRESENTATION

GENERAL OVERVIEW

Data analysis was conducted with the main objectives of this investigation in mind.

1) Evaluate the validity of existing analytical tools for computing springing response and

2) Determine how springing and wave induced stresses combine as maxima.

The primary emphasis for data analysis was placed on head and bow sea data runs, since these runs contained the maximum hull girder stresses recorded during data collection. For the purpose of this report, data runs with wave to ship heading angles of 0 to 15 degrees will be categorized as head sea runs and bow sea runs will be categorized as runs with wave to ship heading angles of 15 to 45 degrees. Data runs are further grouped into loaded and ballast runs to reflect the ship's difference in draft for these runs. This categorization is done for the purpose of grouping similar operating conditions together for the presentation of the data.

MIDSHIP BENDING STRESS RAO's

RAO's were calculated for the CORT main deck vertical bending stress and can be converted to main deck vertical bending moment using the CORT section properties[2] (CORT main deck section modulus = 94,800 in^2- ft). The RAO's calculated, are done so in terms of the ship's encounter frequency, f_e. An RAO for the CORT midship vertical bending stress is simply the response power spectral density S_{Bm} (midship bending stress) at frequency f_e divided by the forcing function power spectral density S_{WH} (wave height) at frequency f_e, and has units of psi^2 / ft^2. Further, the square root of the RAO values are used to facilitate comparison with the analytically generated RAO's and are presented as such. The calculation of the root RAO is described by:

$$\sqrt{RAO}(f_e) = \sqrt{S_{BM}(f_e)/S_{WH}(f_e)} \quad (1)$$

where:

$\sqrt{RAO}(f_e)$ = the root response amplitude operator as a function of encounter frequency,

$S_{BM}(f_e)$ = the response spectral density (bending stress or bending moment) as a function of encounter frequency, and

$S_{WH}(f_e)$ = the wave spectral density as a function of encounter frequency.

The spectral analyses performed were accomplished using the digital data tapes and an FFT algorithm[3] programmed for the PDP 11/03 computer. The parameters of interest for the spectral analyses were a frequency range of from 0 to 2.5 Hz, 256 spectral lines in the specified range, and 28 ensemble averages. The FFT algorithm also processed two channels of data simultaneously and computed the co-spectrum between the two channels. The data was digitized at a rate of 10 samples/second for compatability with the NRL wave measuring system which outputs a digital data signals at this rate. A 5 Hertz sampling rate was used for data analysis by skipping every other data point. If the NRL unit is not employed in future efforts a lower sampling rate should be considered (on the order of 5 Hertz), which would reduce the number of data points to be handled. A sample rate of 5 samples/second still adequately defines the frequencies of interest for this vessel. A maximum ensemble size of 512 points was established for on board data analysis due to the memory size of the PDP 11/03 and the data storage requirements of computing the co-spectrum and power spectrum for two channels simultaneously.

With the sampling rate of 5 Hertz for data analysis, the FFT algorithm used (a full cosine window with 50% overlap), and a record length of 1500 seconds, the spectral analyses performed resulted in 55 degrees of freedom per spectral estimate. The power spectra thus calculated can be defined in terms of the RMS peak to peak amplitude where:

$$RMS_{PK-PK} = \sqrt{8 \cdot \text{AREA UNDER SPECTRUM}} \qquad (2)$$

The term $S_{WH}(f_e)$ in equation (1) is not a term that can be arrived at solely by computing the spectral density from either wave measuring system's range signal. For the case of the Collins Radar, the horns were mounted rigidly to a boom which extended 15 feet forward of the CORT bow and were angled 25 degrees with respect to vertical. The extension and angling of the horns provided a target area for the radar sufficiently forward of the ships' bow wake to eliminate corruption of the encountered wave height measurement.[4] The spectrum of the vertical component of this signal can be calculated directly, but this calculation does not take into account the error introduced into this measurement due to the motion of the ship's bow. To subtract the motion of the ship from the Collins range signal spectrum and arrive at a true wave height spectrum for the Collins radar, an approach using the cross spectrum between the Collins radar and Collins vertical accelerometer was employed.[5] This approach involves manipulations of the Collins vertical acceleration spectrum (from the accelerometer mounted on the Collins radar horns), the Collins range spectrum and the cross spectrum between the two to result in a wave spectrum. The formulation to achieve this:

$$S_{WH}(\omega_e) = S_R(\omega_e) + \frac{1}{\omega_e^4} S_A(\omega_e) - \frac{2}{\omega_e^2} C_{RA}(\omega_e) \qquad (3)$$

where:

$S_{WH}(\omega_e)$ = wave spectral density as a function of encounter frequency

$S_R(\omega_e)$ = vertical component of Collins range signal spectral density as a function of encounter frequency

$S_A(\omega_e)$ = spectral density of the vertical accelerometer mounted on the Collins radar horns as a function of encounter frequency, and

$C_{RA}(\omega_e)$ = cross spectrum of S_R and S_A as a function of encounter frequency.

The measured roll of the ship for the data runs of interest (head and bow seas) was small (less than 1^o) and with the radar horns mounted on the ship longitudinal centerline, the error introduced is considered negligible. Equation (3) was programmed into the onboard computer software to calculate a "corrected" wave height spectrum and convert this spectrum to f_e before the RAO was computed. The magnitude of the correction for ship bow motion was generally on the order of about 5% of the range signal. Figure 4 (a) illustrates the range spectrum, acceleration spectrum, and cross-spectrum between the range and acceleration spectrum for a typical data run in the loaded condition. The corrected wave height spectrum arrived at using equation (3) is illustrated in the Figure 4(b). The midship bending stress spectrum is illustrated in Figure 4(c) and the resulting $\sqrt{RAO}$ is shown in Figure 4 (d). All RAO's presented were arrived at in a similar manner.

Figures 5 through 8 give all the RAO's calculated from the fall trials data for head and bow seas in both the loaded and ballast conditions. The RAO's are given as the root of the RAO (midship vertical bending stress or moment/ foot of wave height) versus encounter frequency, f_e, (Hertz). The RAO's are grouped according to heading (head or bow seas) and draft (loaded or ballast) condition. One will note the slight shift in the RAO peak between the loaded and ballast condition. The shift in the RAO peak is due to the difference in ship draft between the two conditions. This change in draft between the two conditions corresponds to a change in the ship's displacement and the virtual mass of the water acting with the ship; thus producing a change in the ship's natural frequency. This can be seen as true if one considers the relationship between the ship's natural frequency and the ship's actual and virtual mass. The ship natural frequency is seen to vary as the inverse of the square root of the sum of the actual and virtual displacement of the ship. In the fully loaded condition the displacement and virtual mass of the CORT is approximately 200k tons, while in the ballast condition, the displacement and virtual mass of the ship is approximately 175k tons.[6] Using these values one can write:

$$\frac{f_{LOADED}}{f_{BALLAST}} = \sqrt{\frac{\Delta_{ACTUAL+VIRTUAL\,(BALLAST)}}{\Delta_{ACTUAL+VIRTUAL\,(LOADED)}}} \qquad (4)$$

and

$$\frac{f_{LOADED}}{f_{BALLAST}} \approx 0.94$$

The shifting of the $\sqrt{RAO}$ peaks of approximately 6 percent between the loaded and ballast conditions can be attributed to this phenomenon.

One will note the scatter in the $\sqrt{RAO}$ peak magnitudes for the groupings given, and that the peak in the $\sqrt{RAO}$ does not appear to be solely a function of vessel speed, heading or draft based on the data analyzed. The frequency of the $\sqrt{RAO}$ peaks is more consistent for each grouping given. To create a representative springing $\sqrt{RAO}$ for the four groupings given and to assess the variability in the $\sqrt{RAO}$ for each grouping, an average $\sqrt{RAO}$ and standard deviation from the average $\sqrt{RAO}$ were calculated for each grouping. The average $\sqrt{RAO}$ and standard deviation are given in Figures 9 through 12. Both the average $\sqrt{RAO}$ and standard deviation were calculated by computing the average and standard deviation of the magnitude of the $\sqrt{RAO}$'s for a particular grouping at each frequency spacing. As one will note from the figures, the magnitude of the standard deviation is about half of the magnitude of the average $\sqrt{RAO}$ demonstrating the different response characteristics for somewhat similar ship conditions and indicating the sensitivity of springing response to slight changes in heading, draft, and speed, or to possible uncertainty and variability in the wave measurements.

To see if a relationship exists between the wave energy at the springing frequency and the springing response, a plot was made of the peak magnitude of the $\sqrt{RAO}$ versus the square root of the area under the wave height spectrum eight frequency lines to either side of the peak in the springing response spectrum. This plot is given in Figure 13(a). A similar plot was made of the peak magnitude of the $\sqrt{RAO}$ versus the measured significant wave height. This plot is given in Figure 13(b). Plotting the data in either manner shows no discernable trend as to a relationship between springing response and wave energy at the springing

frequency or springing response and overall wave energy. This is as expected since the $\sqrt{RAO}$'s exhibited large scatter for small changes in ship operating and environmental conditions.

COMPARISON OF MEASURED AND THEORETICAL MIDSHIP BENDING MOMENT RAO's

Eight data runs were selected for comparison of measured and analytically calculated RAO's. The selection of measured data runs for comparison was done primarily on the basis of using those data runs where a predominant sea existed from one direction (as best that could be visually determined) even though it is realized that some wave spreading still occurs. Additionally, it was desired to have as many ship operating parameters (draft, speed, heading) varied as was possible in varying sea states, to see how the existing analytical tools predicted the ship's response characteristics for these varying parameters. The eight data runs selected are given in Table 2 along with the respective ship parameters that existed when the data was taken. The measured significant wave heights for these data runs are also given in Table 2.*

The input parameters (ship speed, ship drafts forward, amidship, and aft, and wave to ship angle) were supplied to the American Bureau of Shipping (ABS) and Webb Institute of Naval Architecture (Webb) for the calculation of RAO's for these cases. The first mode natural bending frequency of the CORT was also supplied to Webb as this parameter is also an input parameter for their analytical formulation. The analytical RAO's and the measured RAO's for these cases are given in Figures 14 through 21. (ABS - APPENDIX E; Webb - APPENDIX G)

To assess how each analytical model predicts the springing bending moment response of the CORT, the analytical RAO's were squared and multiplied by the measured wave spectrum for each case to arrive at a springing bending moment response spectrum for the analytical RAO's. The springing bending moment response

*(APPENDIX D contains time histories for these 8 conditions in Table 2.).

spectra thus arrived at from both analytical RAO's and the actual measured bending moment response spectrum for each case are given in Figures 22 through 29. It is worth noting that for some cases the WEBB response spectra are plotted to a different scale. The significant springing bending moment (average of the 1/3 highest peak to peak variations) were calculated from these response spectra by taking the square root of the area under each spectrum and multiplying by four. The significant springing bending moments thus arrived at are given in Table 3. From Table 3 one will see that the ABS model's significant springing bending moments compare fairly well with the measured bending moments, while the WEBB bending moments tend to be larger than the measured bending moments by about a factor of two. (For additional calculations see APPENDIX F (U. of Mich) & APPENDIX H (DnV))

COMBINING OF WAVE INDUCED AND SPRINGING STRESSES AS MAXIMA

The manner in which the wave induced and springing components of the midship vertical bending stress combine was analyzed in the frequency domain. In the frequency domain, the statistical properties of the midship vertical bending stress spectrum were employed to see how these two components of the midship bending stress spectrum combine to form a maxima. A typical response spectrum is shown in Figure 4. The spectrum contains two peaks. The first peak at the lower frequency is the wave induced portion of the vertical bending response and the second peak at the ship hull natural frequency ($\sim$ .34 Hz) corresponds to the ships springing response.

For a narrow band single peaked spectrum the number E represents the mean squared value of the peak to peak variations of the individual frequency components which make up the ship's response. For a double-humped spectrum like the one given in Figure 4(c), the area under each hump represents the sum of the squares of the individual frequency components which make up that portion (springing or wave

induced) of the ship's response. Additionally, for a narrow band spectrum of a random variable with a zero mean such as the springing and wave induced portions of the midship bending moment, the area under the spectrum is equal to one eighth the mean squared value of the peak to peak variations, so that:

$$A = \text{area under power spectrum} = \frac{1}{8}\sum_{i=1}^{N}\frac{Y_i^2}{N} = \frac{E_p}{8} \tag{5}$$

where:

Y_i - is the i^{th} peak to peak variation (crest to trough), and

E_p - is the mean squared value of the peak to peak variations.

Further, if the sample contains N peak to peak variations (with N 100) the probable maximum peak to peak value of Y is given as[7]:

$$Y_{MAX} = \sqrt{E_p \log_e N} \tag{6}$$

The use of E_p in equation (6) gives an estimate of the maximum peak to peak variation in the set. However, this need not be indicative of the maximum single amplitude excursion that occurs (i.e., mean to peak). The midship bending response is comprised of a springing component which has a relatively constant frequency, but varying amplitudes and a wave induced component which has varying frequencies as well as amplitudes. As such, the maximum single amplitude peak (with respect to the mean) need not be (and generally is not) equal to one half the maximum peak to peak variation in the record, but is somewhat larger. Therefore, a method for predicting how wave induced and springing stresses combine should be one which predicts the maximum single amplitude peak in the record and should be compared against the measured maximum single amplitude peak.

One can estimate the probable maximum peak value for either the springing or wave induced component of the combined response by calculating the area under the springing or wave induced portion of the combined response spectrum ($E_p = 8 \times$ Area) determining the respective number of variations in the sample record N, and employing the following relationship:

$$Y_{MAX-PEAK} = \sqrt{\frac{1}{4} E_p \log_e N} \tag{7}$$

If one were to add the probable maximum peak responses calculated using equation (7) for the springing and wave induced components of the response spectrum, one would have

$$Y_{MAX-COMB} = Y_{MAX-SPR-PK} + Y_{MAX-WAVE-PK} = \sqrt{\frac{1}{4} E_{P_{SPR}} \log_e N_{SPR}} + \sqrt{\frac{1}{4} E_{P_{WAVE}} \log_e N_{WAVE}} \tag{8}$$

Where,

$Y_{MAX-COMB}$ – is the probable maximum combined peak response when the maximum springing and wave induced responses occur simultaneously:

E_{SPR} – is the mean squared value of the peak to peak springing variations:

E_{WAVE} – is the mean squared value of the peak to peak wave induced variations, and

N_{SPR}, N_{WAVE} – is the respective number of springing and wave induced variations in the sample record. Each N can be approximated by multiplying the frequency at each respective peak in the spectrum by the run length.

Using equation (8) one would arrive at the probable maximum peak variation when the springing and wave induced components were both a

maximum and occurring simultaneously. The probability of this occurring is $1/(N_{SPR} \times N_{WAVE})$ and leads to a generally, but not always conservative estimate of the maximum bending moment response. Table 4 gives the maximum peak responses calculated from the data using equation (8). Also given in Table 4 are the actual peak values recorded for that particular data run and the ratio of calculated peak response to measured peak response times 100 percent. As an indication of how equation (8) predicts the maximum peak response, the ratio of calculated expected maximum response to actual measured maximum response x 100 percent is plotted versus frequency of occurrence in Figure 30. The existing data base is somewhat limited, but one can see that this method of combining springing and wave induced responses, although somewhat empirical, generally provides a conservative estimate of the expected maximum peak bending stress. If a larger data base were available to better define the shape of the histogram one would be able to assign a confidence limit factor to equation (8) from the histogram so that one would be assured that equation (8) predicted at least the maximum expected response a certain percentage of time. The small data base and relatively poor definition of the histogram as it now exists precludes the use of the formulation for predicting a maximum response with any degree of certainty. A possible follow on effort to increase the data base and better define the histogram shape would be to similarly analyze the midship bending stress records collected from previous seasons on the CORT. This additional data could then be incorporated with the 79 season data and an estimate of a confidence limit factor arrived at for implementing equation (8).

MAXIMUM DECK EDGE AND MIDSHIP TORSIONAL STRESS

Midship lateral bending stresses were recorded to determine the magnitudes of these stresses and to determine whether these magnitudes were sufficiently large to produce an unsafe deck edge stress when combined with the midship vertical bending stress. A typical midship lateral bending stress response spectrum is given in Figure 31. The lateral bending stress response spectrum is similar to the vertical bending stress response spectrum in that it contains two peaks where the response energy is concentrated. The first peak (low frequency) corresponds to the wave induced lateral bending energy and the second peak (high frequency) corresponds to the ships first mode lateral bending frequency. From the runs analyzed, the first mode lateral bending frequency is approximately .76 Hertz in the fully loaded condition (27 foot draft) and approximately .92 Hertz in the ballasted condition (approx 19 foot forward draft). A listing of the peak lateral bending stress (single amplitude) and the peak vertical bending stress (single amplitude) for the bow sea runs examined is given in Table 5. Also given in Table 5 are the peak deck edge stresses measured for those same data runs. The deck edge stresses were arrived at by adding the vertical and lateral bending stresses in the time domain to produce a time history of the deck edge stress. A peak analysis of this time history was then done to determine the maximum single amplitude deck edge stress in the record. Based on this analysis, the lateral bending stresses when combined with the vertical bending stresses tend to produce a maximum deck edge stress which averages about 8 percent higher than the maximum vertical bending stress recorded for these data runs.

Midship torsional stress was also recorded throughout these trials. The midship torsional stresses recorded were very small and a single amplitude peak stress of greater than 200 psi was never attained. This is due in part to the concentration of data collection on predominantly head sea conditions, although large midship torsional stresses still weren't realized for any of the bow sea cases either. A listing of the maximum single amplitude torsional stresses recorded is given in Table 6 for the bow sea runs examined.

COMPARISON OF COLLINS RADAR AND WAVE RIDER BUOY MEASUREMENTS

Two data runs (runs 70, 71) were completed during the 1979 trials season when a wave rider buoy was deployed in the immediate vicinity of the ship by a USCG helicopter assigned to USCGAS Traverse City. The buoy was picked up by helicopter from the ship's deck and deployed three miles forward of CORT and directly on the ship's course. Data was collected from the buoy, in addition to all other sensors comprising the CORT data acquisition system, as the ship approached the buoy and overtook it. Data collection was terminated when the ship was out of signal range of the buoy. Both data runs were taken one after the other while downbound on Lake Michigan and were approximately 20 minutes in duration. Subsequent attempts at obtaining buoy correlation data runs were unsuccessful due either to ship location during daylight hours, (e.g. outside the range of a helicopter station) or to weather too severe for safe helicopter operations.

Comparisons between wave height power spectral densities calculated from the wave rider buoy and Collins radar for runs 70 and 71 are given in Figures 32 and 33 respectively. These figures give the wave height power spectral density as a function of wave frequency. To arrive at the Collins

radar wave height power spectral density as a function of wave frequency, the corrected (for ship motions) Collins wave height spectrum was first calculated as a function of encounter frequency using equation (3) and then converted to wave frequency using the relationship:

$$S_{WH}(\omega) = S_{WH}(\omega_e) \left| 1 + \frac{2\omega}{g} V_s \cos\theta \right| \tag{9}$$

The buoy wave height power spectrum was calculated by dividing the buoy acceleration power spectral density as a function of ω by its respective frequency to the fourth power, or

$$S_{WH}(\omega_i)_{BUOY} = S_A(\omega_i)_{BUOY} / \omega_i^4 \tag{10}$$

One will note in both Figures 32 and 33 that the buoy spectra are labeled "corrected." This is because the original signal sensitivity supplied with the buoy and receiver was in error. A calibration of the buoy in a NOAA dynamic wave rider buoy calibrator subsequent to the completion of fall trials showed the buoy calibration sensitivity to be linearly increasing with increasing frequency with respect to the original calibration sensitivity. This correction was applied to the originally calculated buoy spectra to arrive at the buoy spectra shown in Figures 32 and 33.

As is evidenced by Figure 32 the buoy and Collins Radar wave heights compare reasonably well, with the buoy indicating a significant wave height of 2.32 ft and the Collins Radar indicating a significant wave height of 2.97 ft. These numbers agree well with the 2 to 4 ft waves visually observed. The lesser agreement between the buoy and Collins radar for run 71 can be attributed to the buoy passing to the ships leeward side for a portion of the

data run. The CORT wake on this day was knocking down the waves for a few ship lengths beyond the stern. The buoy spent a good portion of run 71 riding through this relatively calm (with respect to the surrounding sea) stretch of water. Runs 70 and 71 were completed in succession and in less than one hour with the sea diminishing. The significant wave height indicated by the Collins Radar is 2.13 ft for run 71 while the buoy indicates a singificant wave height of 1.72 ft. It is doubtful that the sea had diminished as much as is indicated by the wave huoy (and visual estimates tend to reinforce this). Rather it is felt that the passage of the buoy through the ship wake for most of the data run caused the buoy to indicate the lower sea conditions. The ship's wake was not a consideration for run 70 as the buoy passed the ship to the windward side and never entered the ship's wake.

Based on the reasonable agreement between the Collins Radar and wave buoy significant wave heights from these runs and the agreement of the Collins radar with visual observations of wave heights throughout the fall trials, it is felt that the Collins Radar altimeter gives a good representation of the existing sea. More buoy correlations would obviously lend more credibility to both the Collins and the buoy as wave measuring devices and should be planned for any future efforts.

FULL SCALE PRESSURE DISTRIBUTION MEASUREMENTS

Current Ship Structure Committee (SSC) computer programs deal primarily with sea loads imposed on the hull girder. In addition, knowledge of pressures on the hull surface is also needed to determine the required strength of local structures to withstand maximum anticipated pressures at sea. Since computer programs for calculating pressure distributions are available to the profession, it is worthwhile to verify the results of computations by model and full scale experiments.

The Coast Guard, considering the potential value of full-scale pressure measurements, took advantage of the five-year drydocking/hull inspection yard period, and with the cooperation of Bethlehem Steel installed 15 inserts in the forward quarter length of the CORT hull plating. Pressure transducers were then installed in the inserts without a drydocking. The pressure gage locations were given in Figure 3b. The results obtained from full-scale pressure measurements have the potential for wide use verification of computed theoretical pressures and correlation between full and model scale measurements.

The pressure data was collected in conjunction with the wave/stress measurements and stored on magnetic tape. Consistency and reasonableness of the collected data was checked by examining pressure gage time histories and calculating pressure power spectra and RAO's. Reduced data in the form of pressure power spectra were delivered to ABS for the data runs they requested. These hull pressure power spectra will be used by ABS to evaluate existing formulations of potential theory computer programs.

Typical response spectra (from Run 77) calculated from the gages located at Frame 9 are given in Figure 34. Also given in Figure 34 is the measured wave spectrum from this data run. Figure 35 gives the resulting RAO's calculated for these gages. The spectra given in Figure 34 and the RAO's in Figure 35 represent the dynamic pressure fluctuations seen by the ship hull as it encounters waves. The static head due to the location of these gages below the waterline has been electronically subtracted out using the data acquisition signal conditioning. To get the actual pressure at a particular gage location, the pressure due to the static head must be added on. It is worth noting that for any future use of these data tapes, pressure gages six and fourteen should be considered unreliable (see page 5).

M/V STEWART J. CORT MEASURANDS

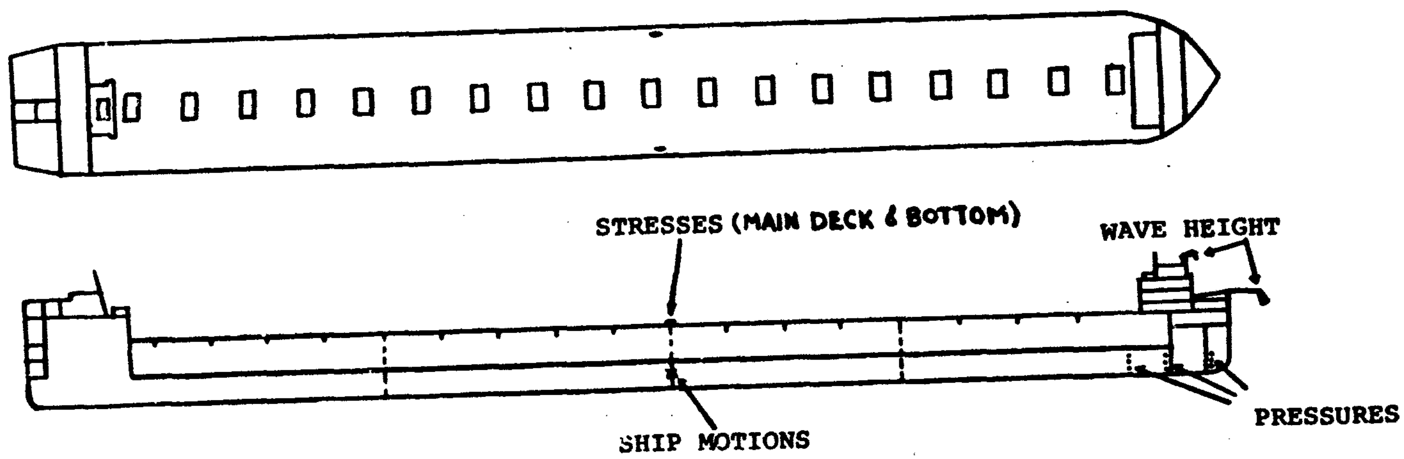


Figure 1 - General Sensor Locations on the Ship

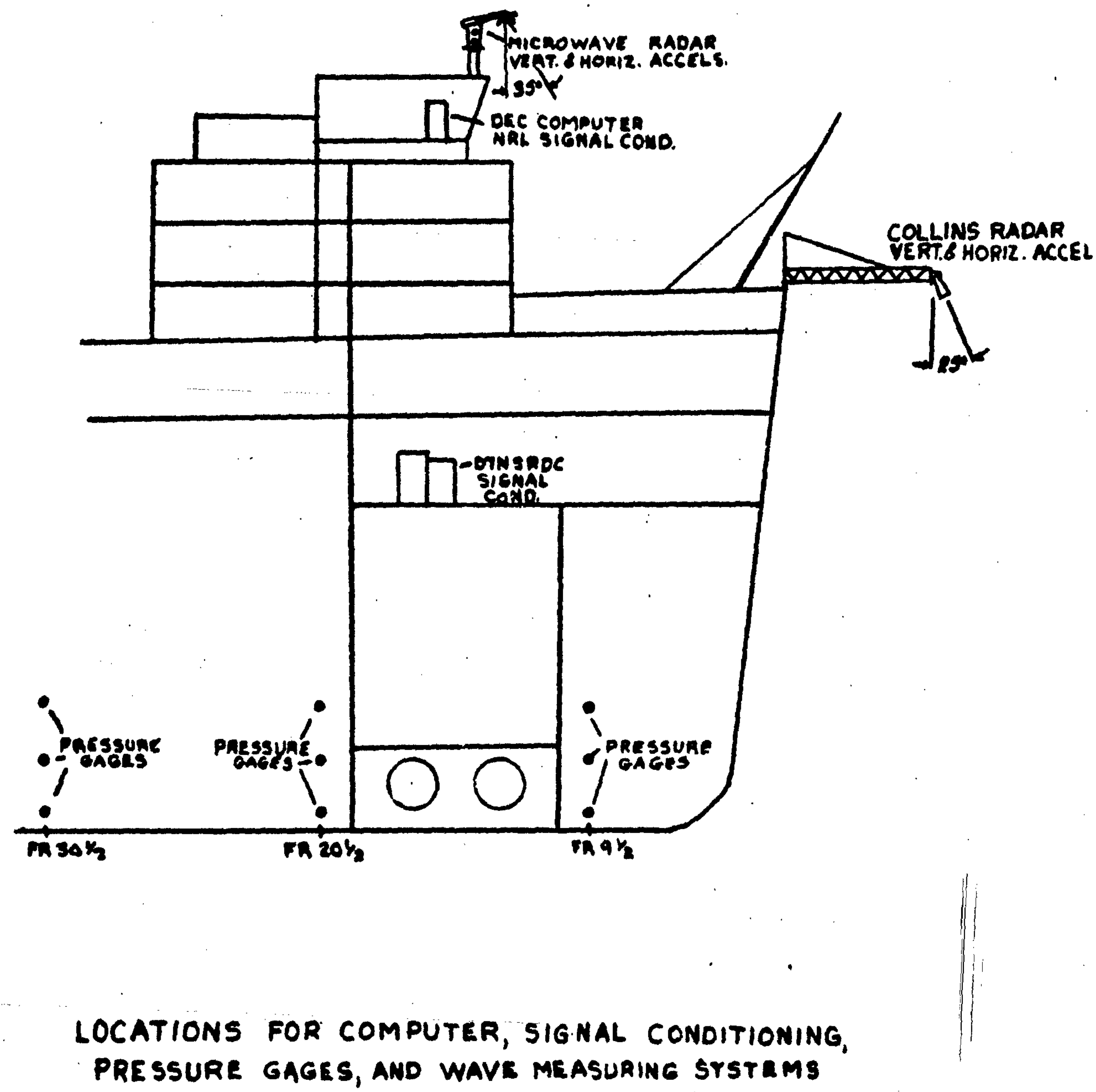
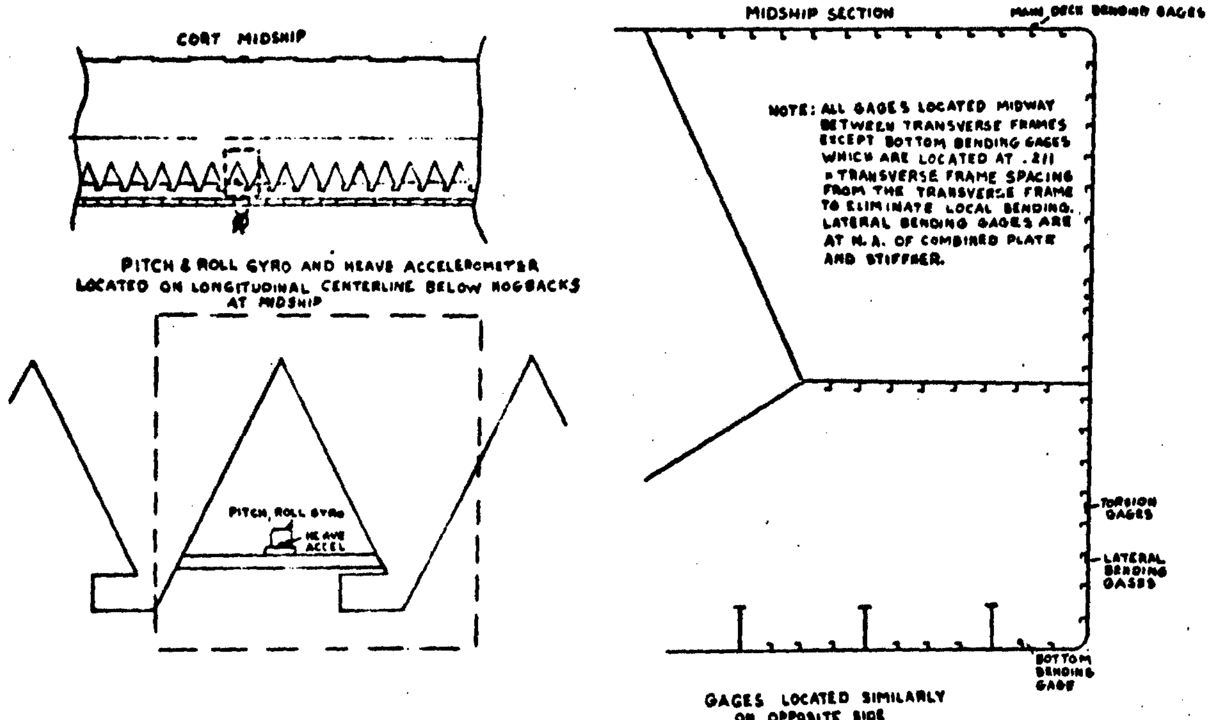


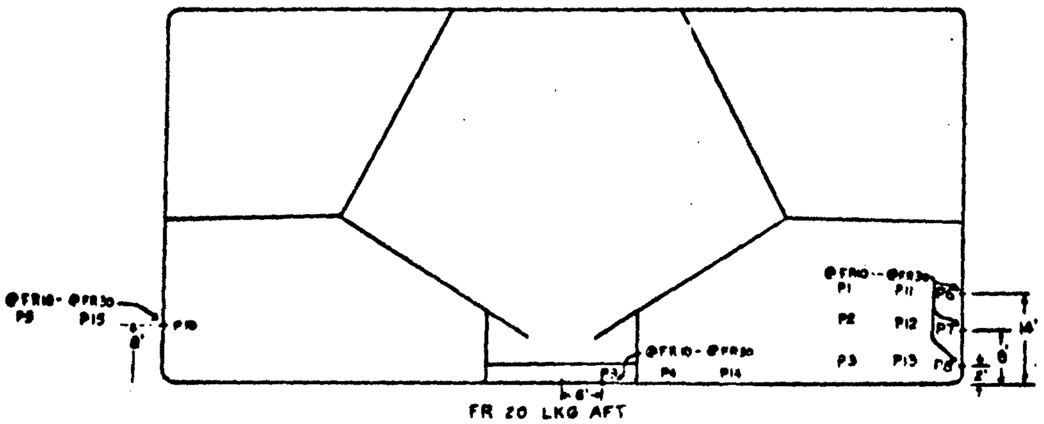
Figure 2 - Forward Measurands and Data Acquisition System Locations



LOCATIONS OF PITCH, ROLL, AND HEAVE SENSORS

LOCATIONS OF MIDSHIP STRAIN GAGES

FIGURE 3(a)
MIDSHIP MEASURAND LOCATIONS



SAME GAGE ARRANGEMENT BTW FRS 9/10 & 30/31

FIGURE 3(b)
PRESSURE GAGE LOCATIONS ON M/V S.J. CORT

Figure 3 - Midship Measurand Locations

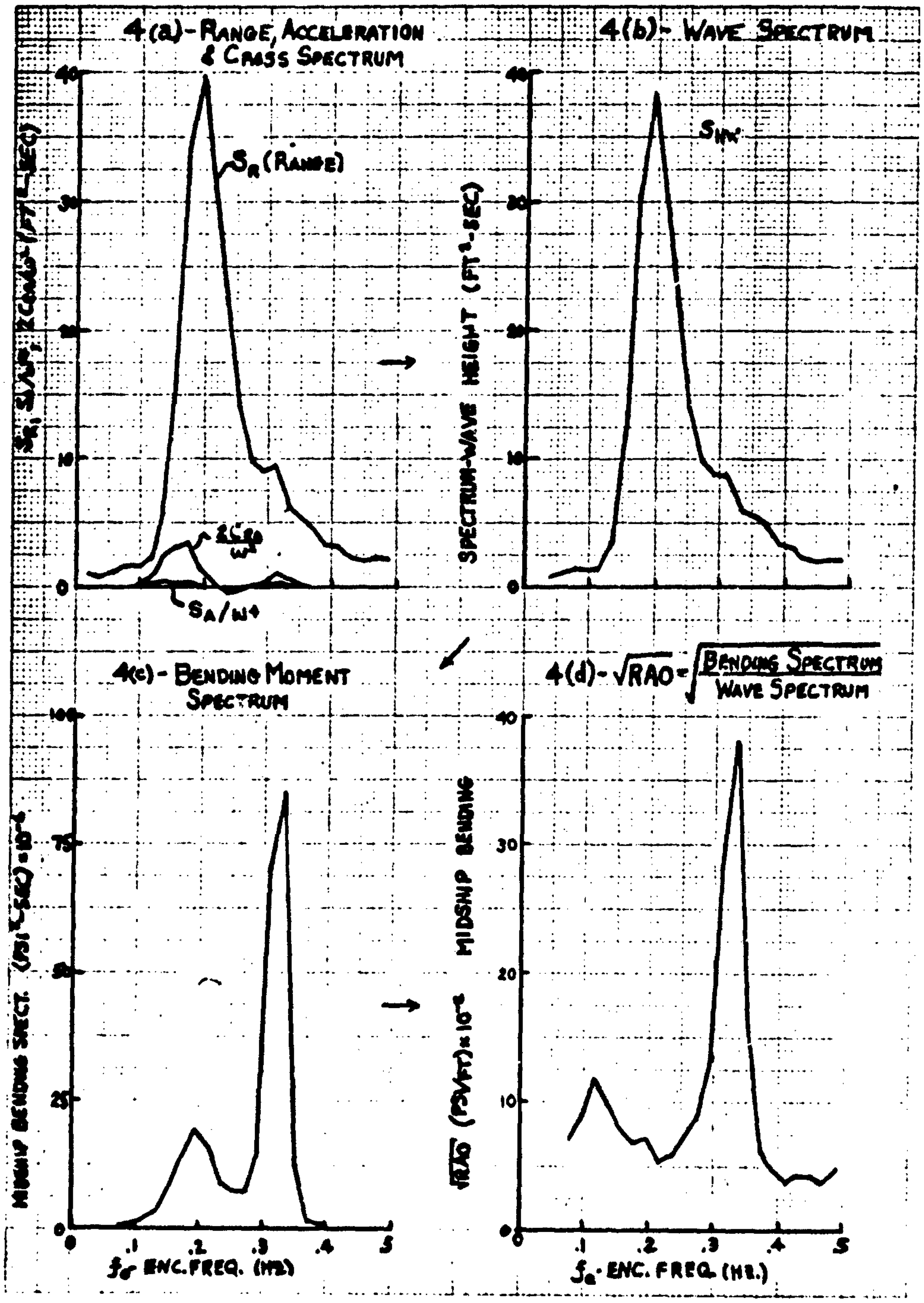


Figure 4 - Method of Wave Height and RAO Calculation

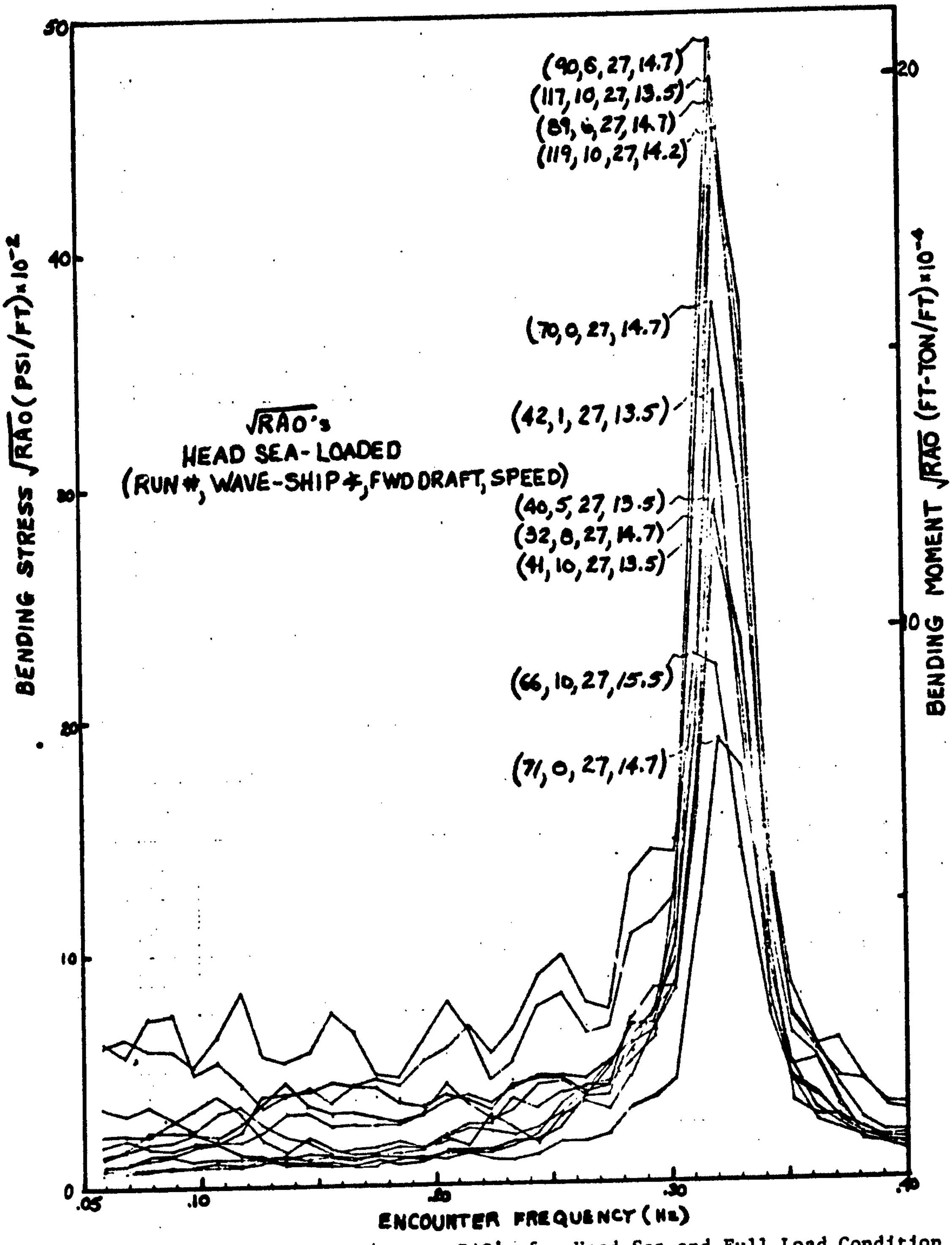


Figure 5 - Bending Stress/Moment RAO's for Head Sea and Full Load Condition

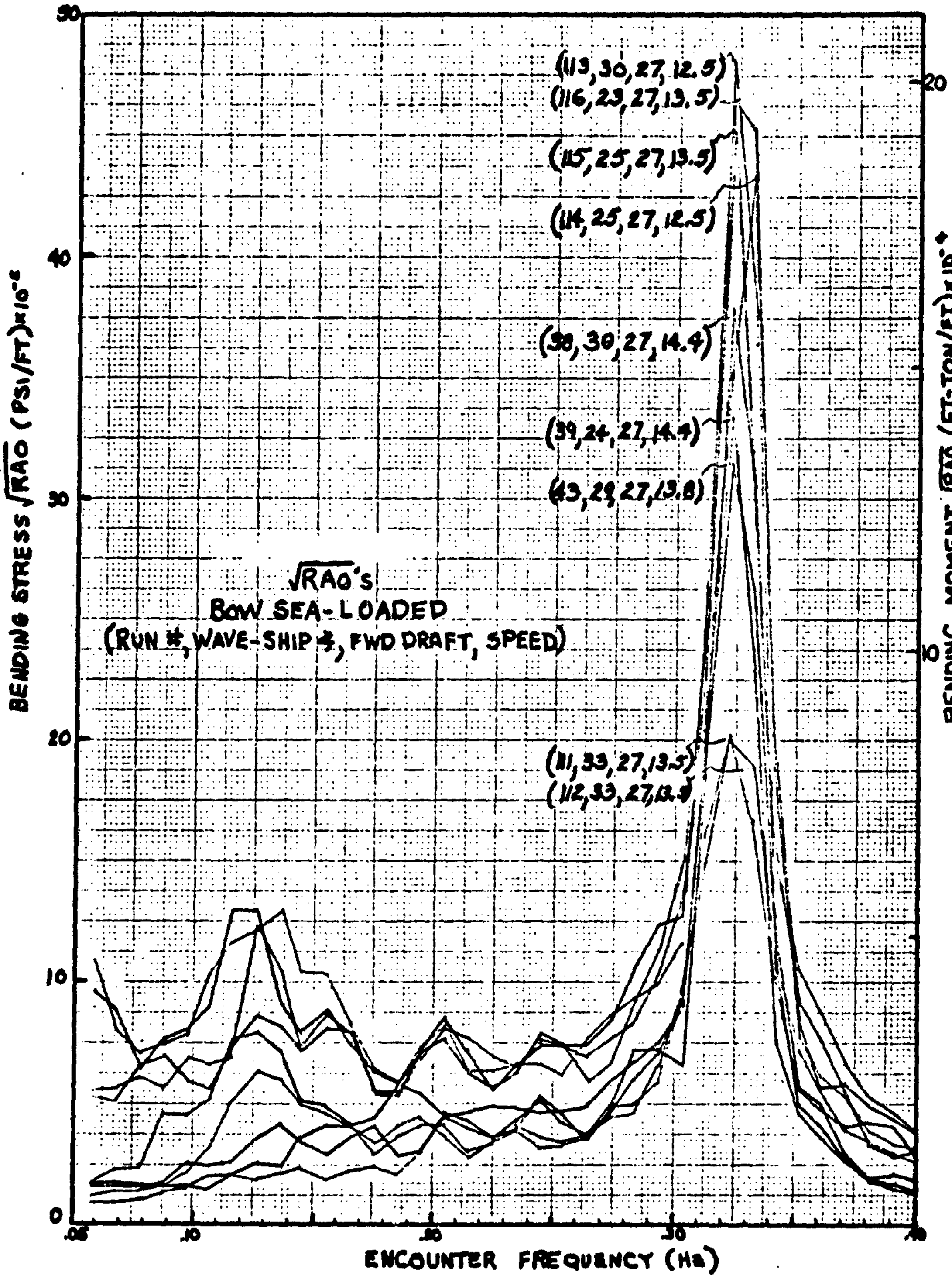


Figure 6 - Bending Stress/Moment RAO's for Bow Sea and Full Load Condition

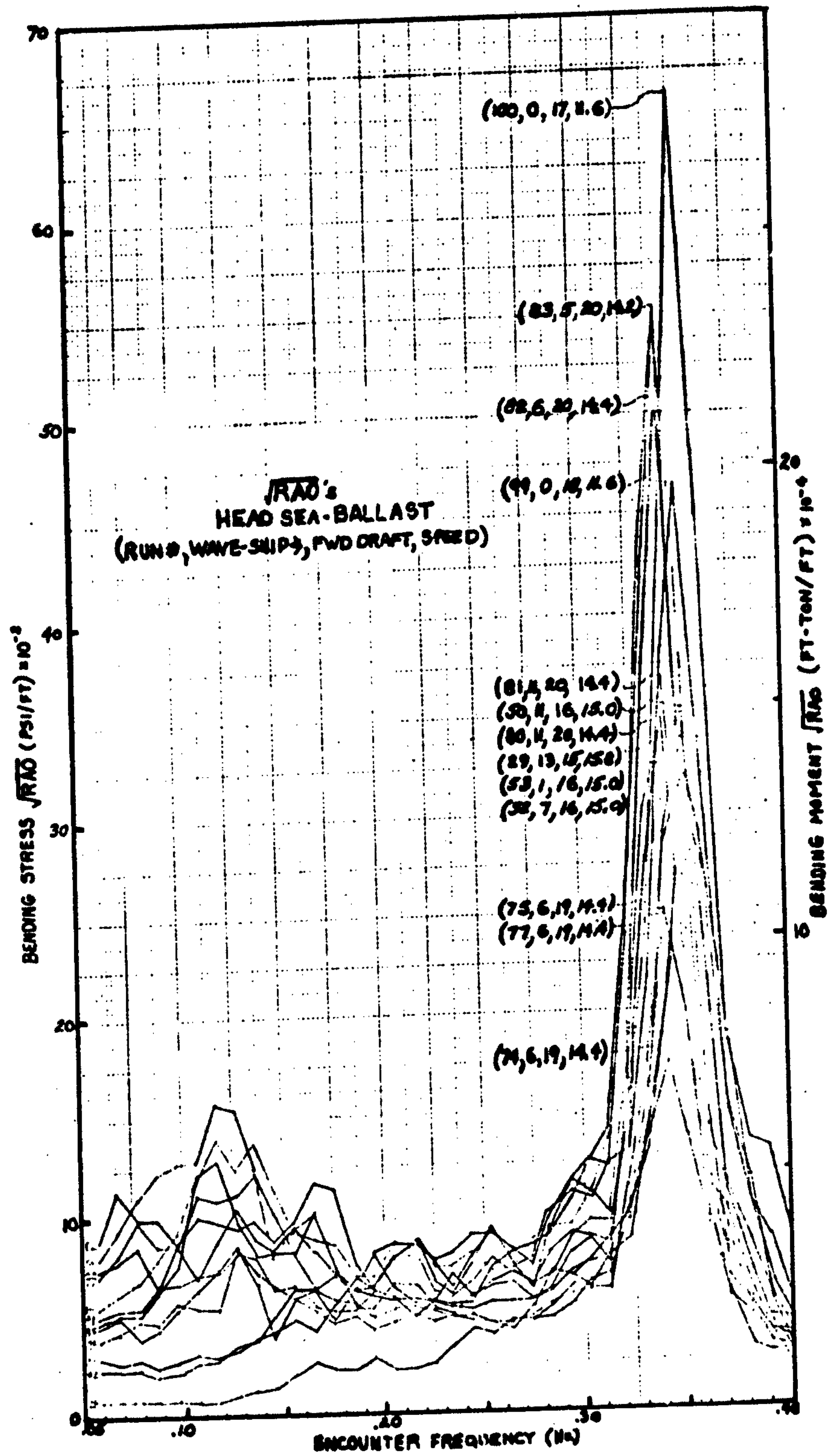


Figure 7 - Bending Stress/Moment RAO's for Head Sea and Ballast Conditions

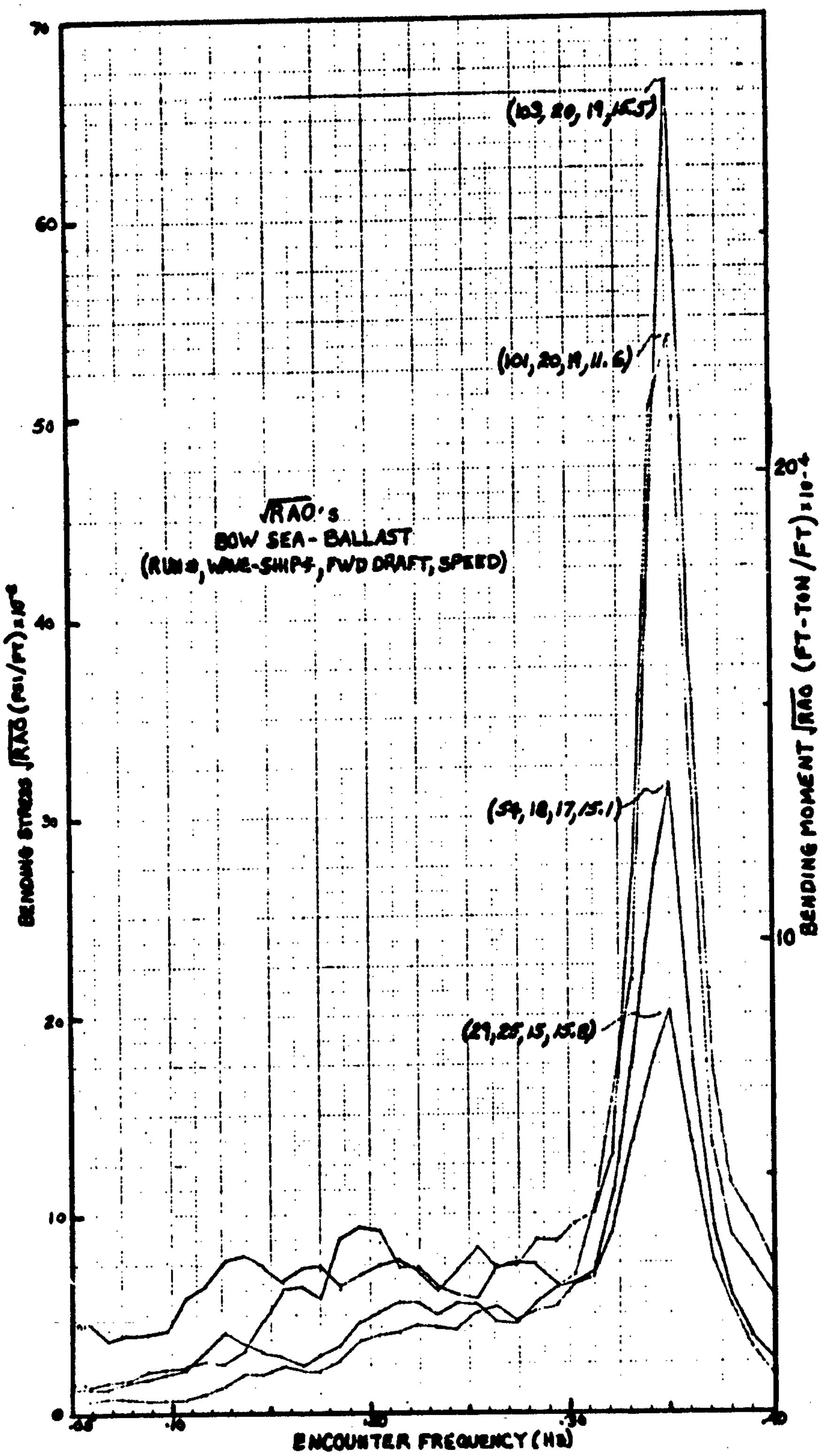


Figure 8 - Bending Stress/Moment RAO's for Bow Sea and Ballast Conditions

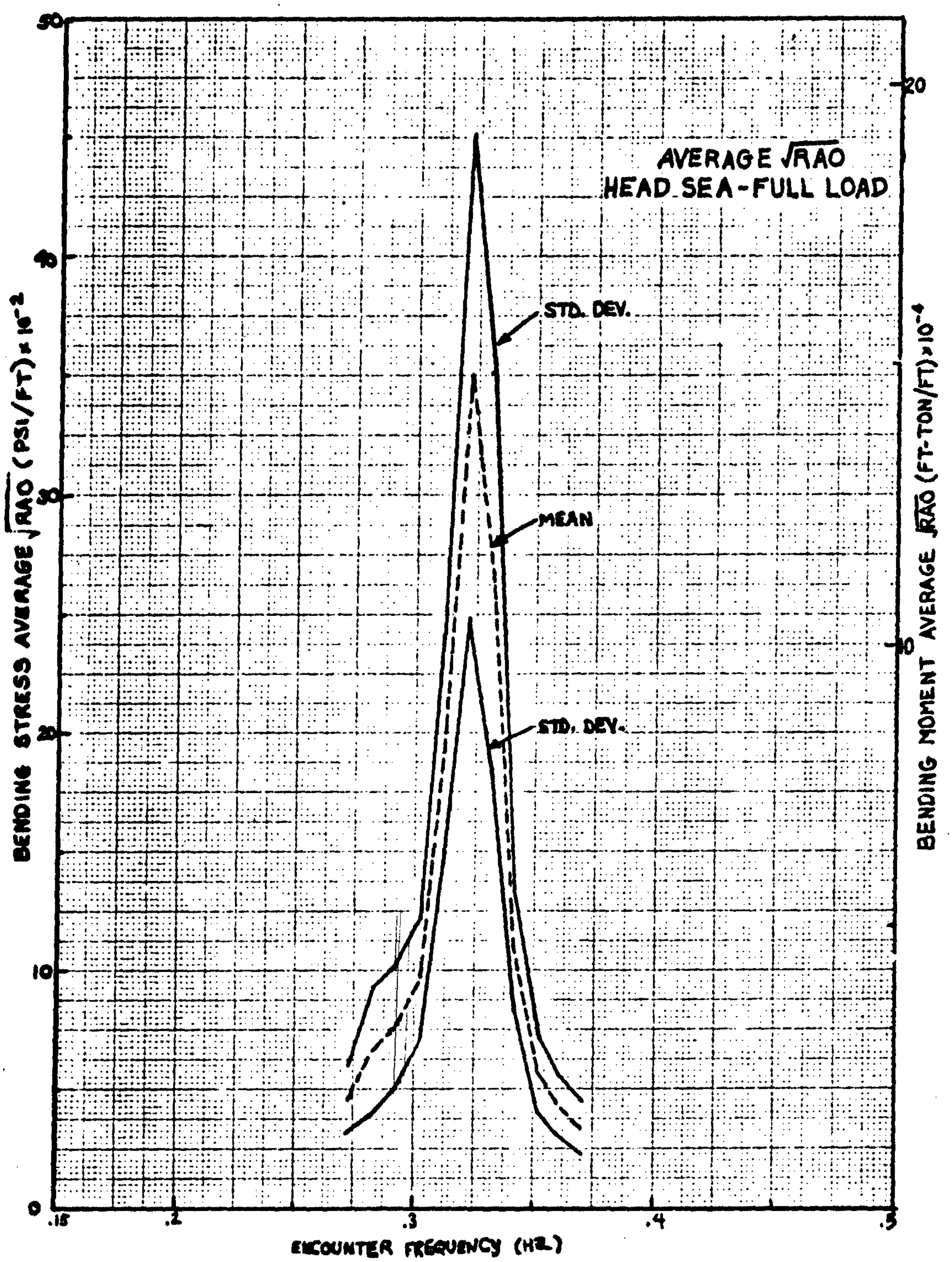


Figure 9 - Average RAO and Standard Deviation fcr Head Sea and Full Load Conditions

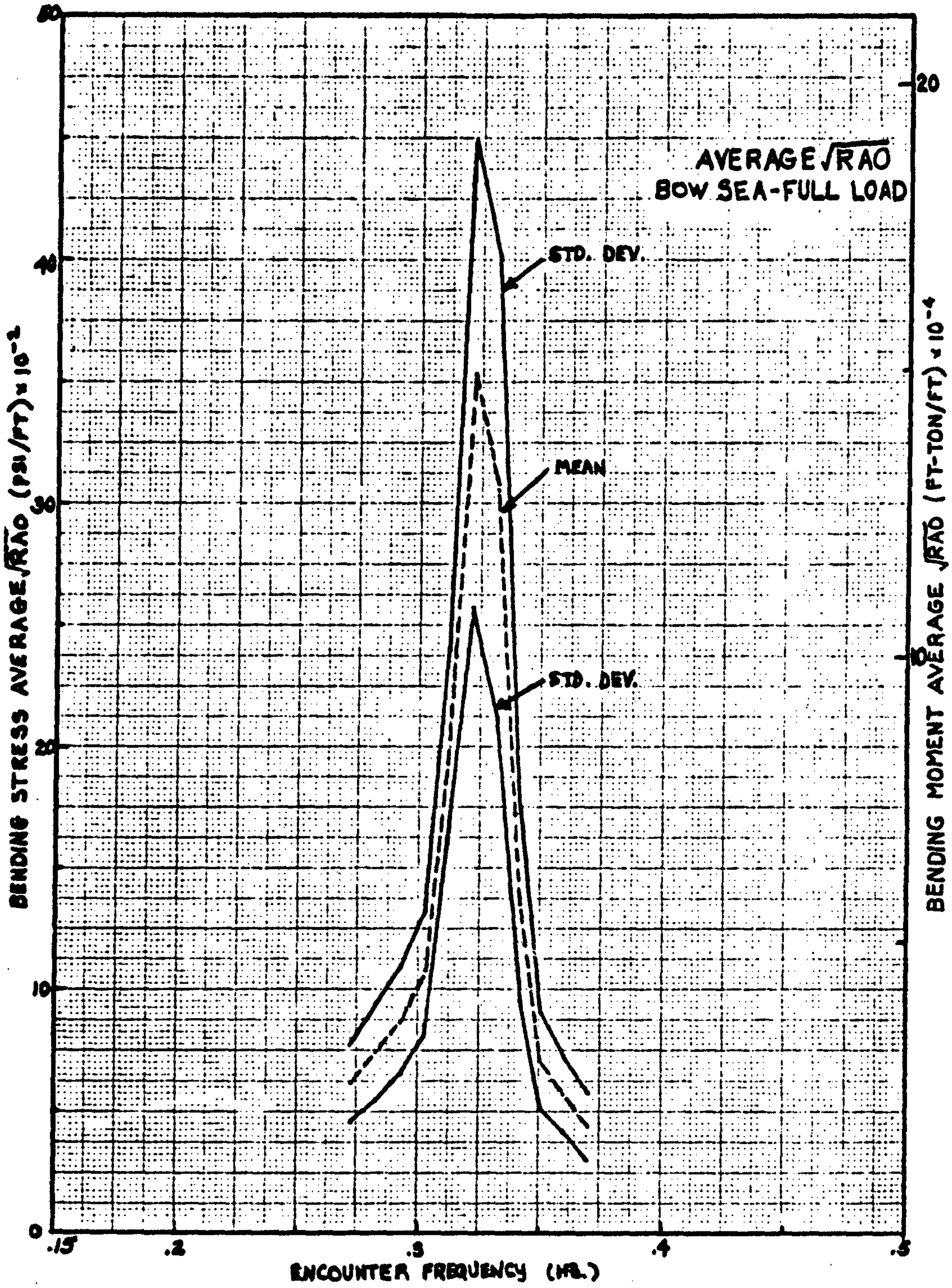


Figure 10 - Average RAO and Standard Deviation for Bow Sea Full Load Conditions

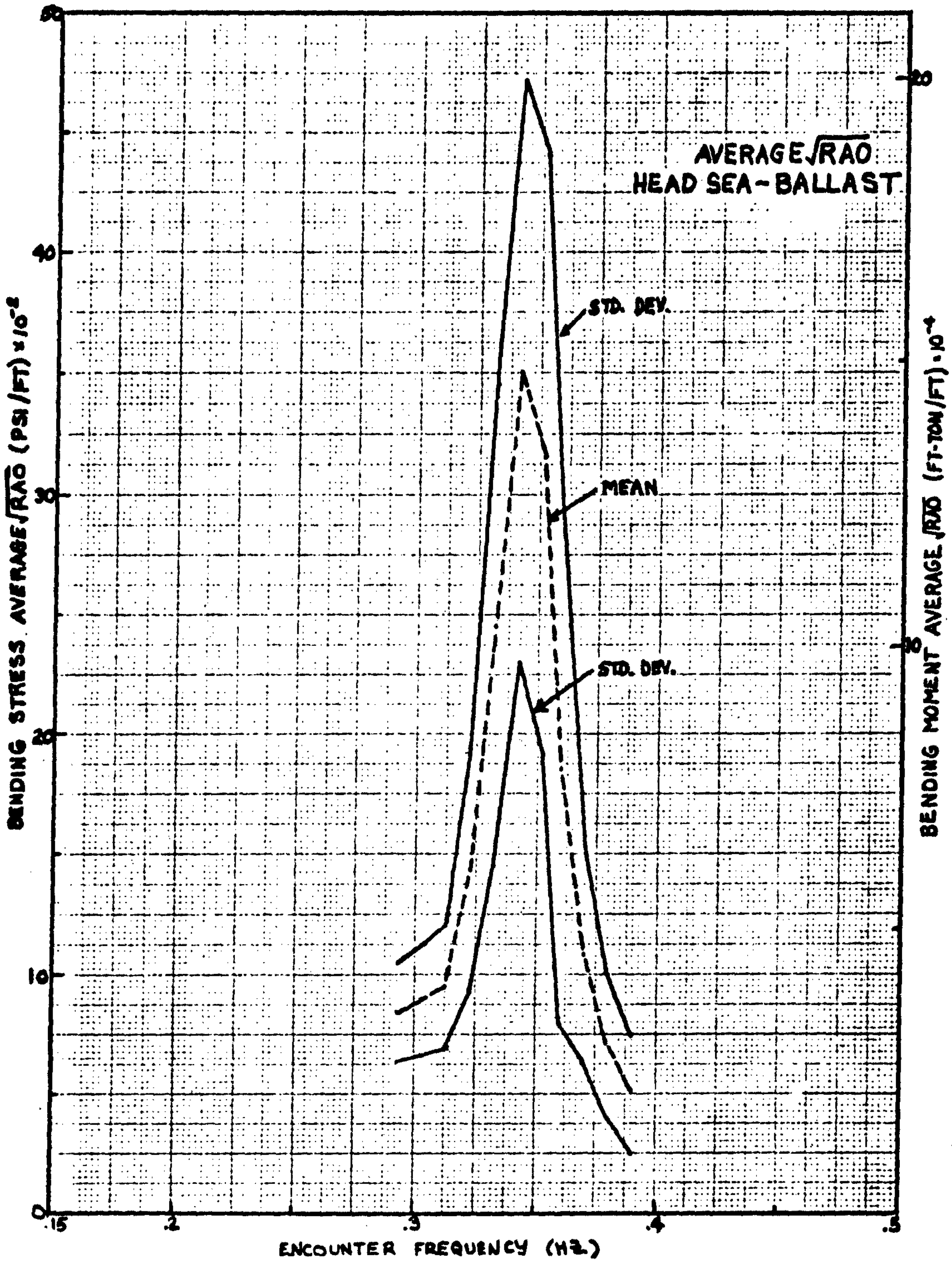


Figure 11 - Average RAO and Standard Deviation for Head Sea and Ballast Conditions

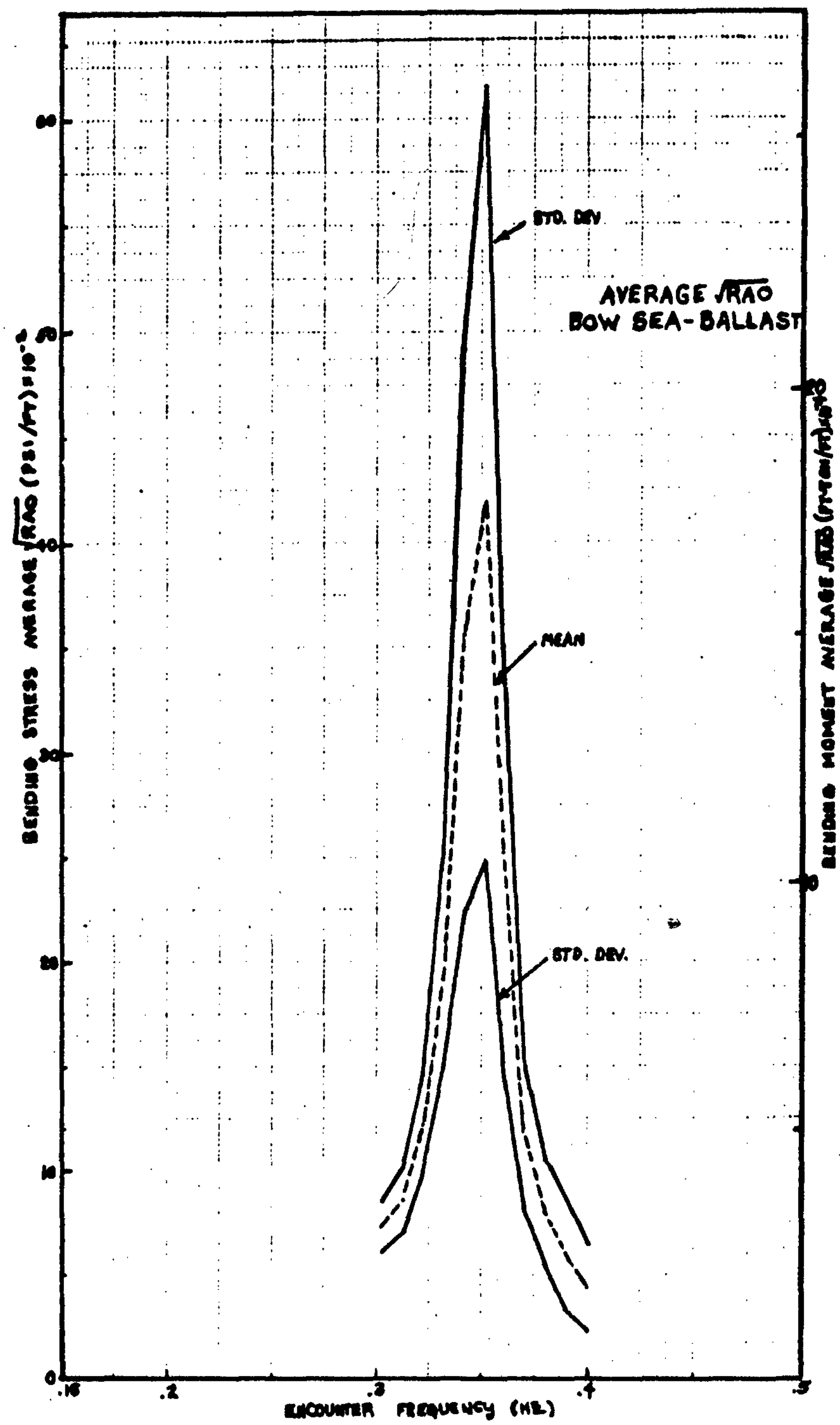
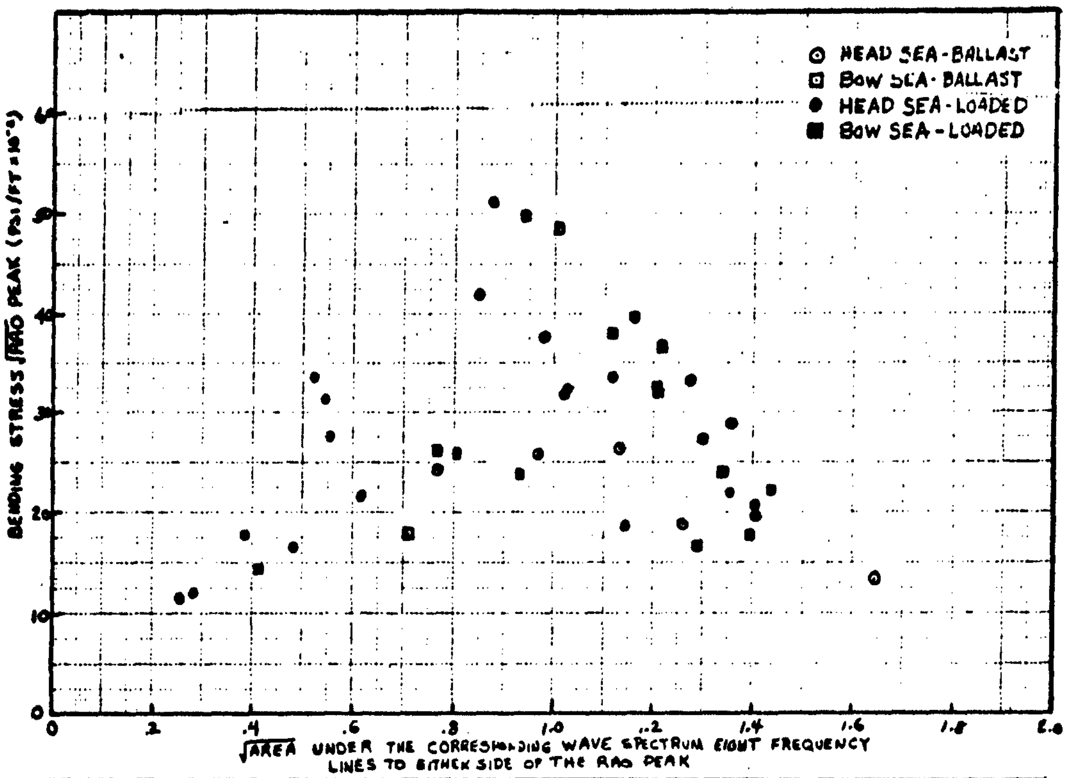


Figure 12 - Average RAO and Standard Deviation for Bow Sea and Ballast Conditions



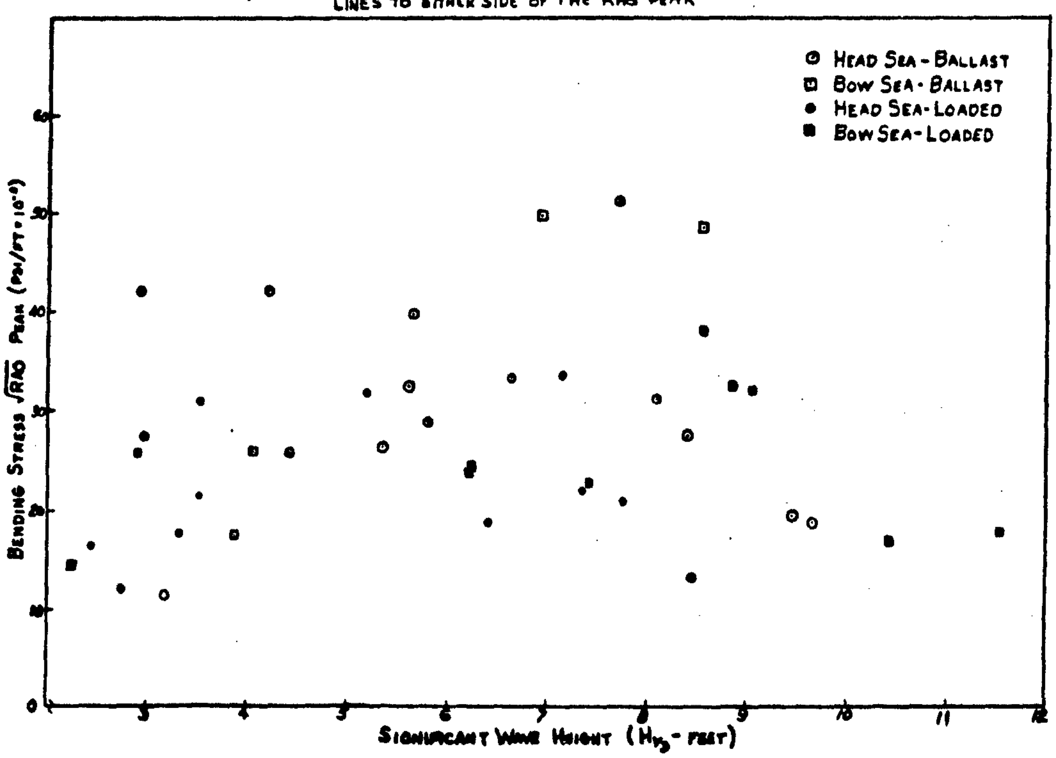


Figure 13 - RAO Peak versus Wave Energy

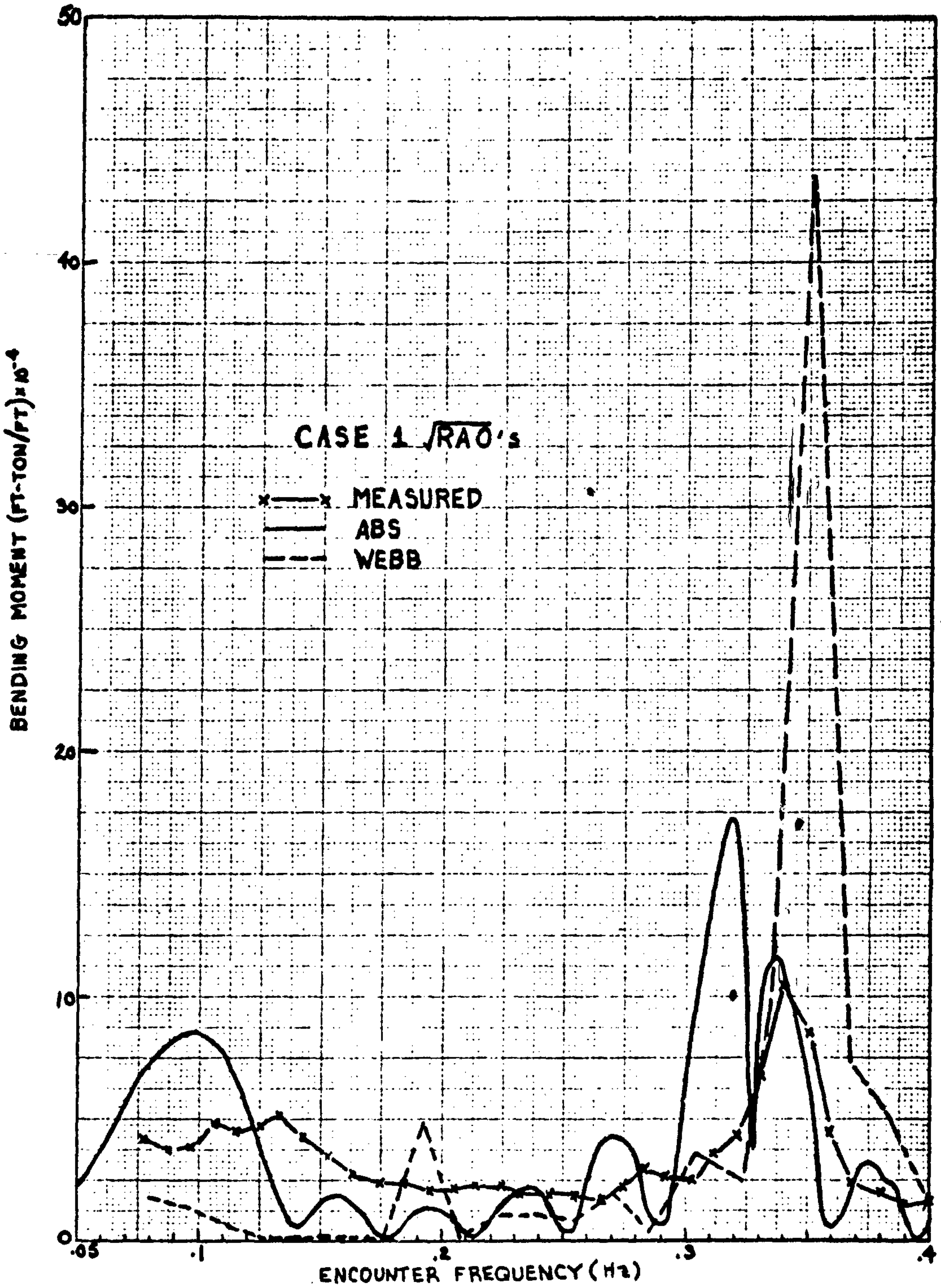


Figure 14 - Comparison of Measured and Analytical RAO for Case 1

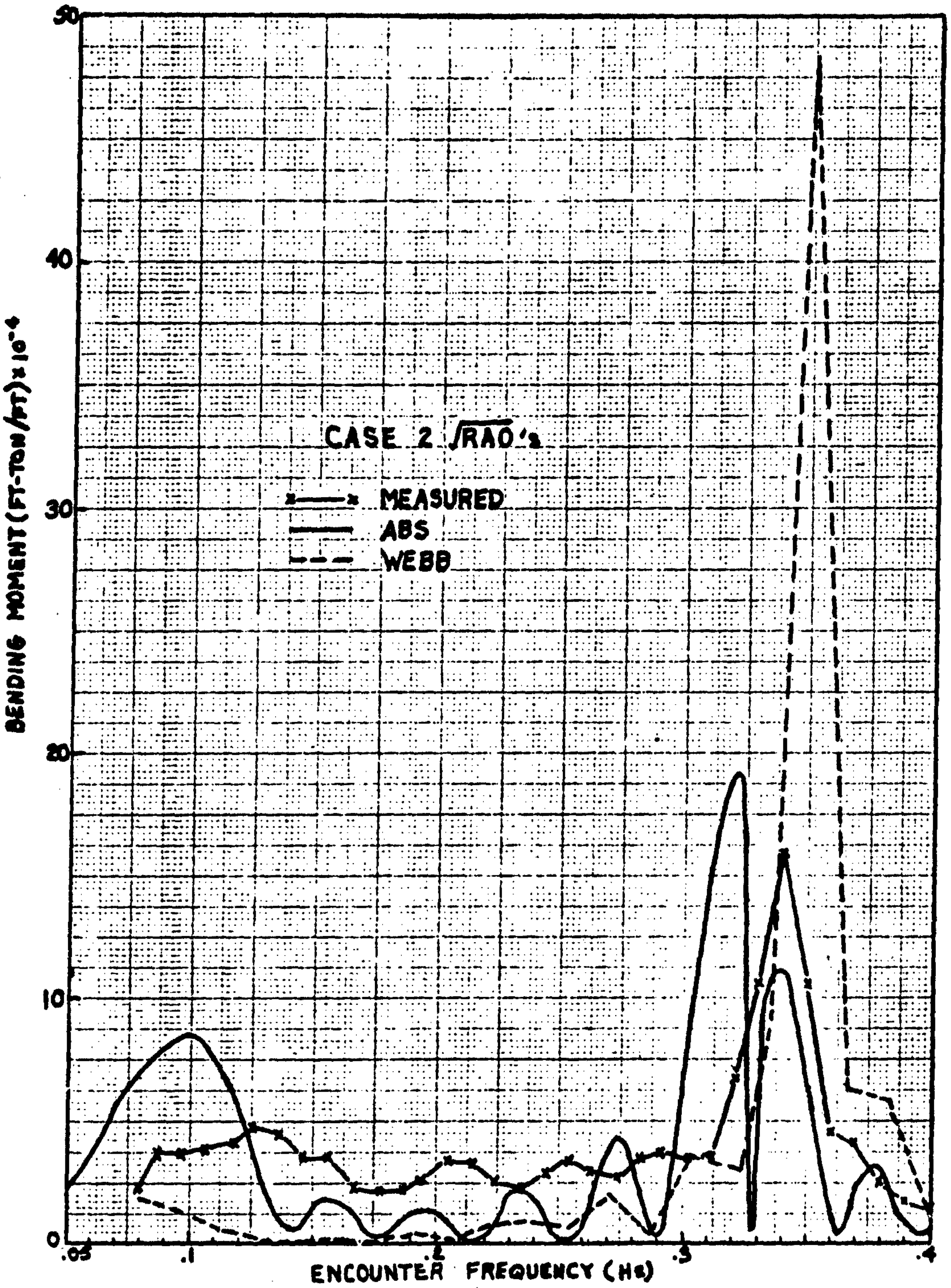


Figure 15 - Comparison of Measured and Analytical RAO for Case 2

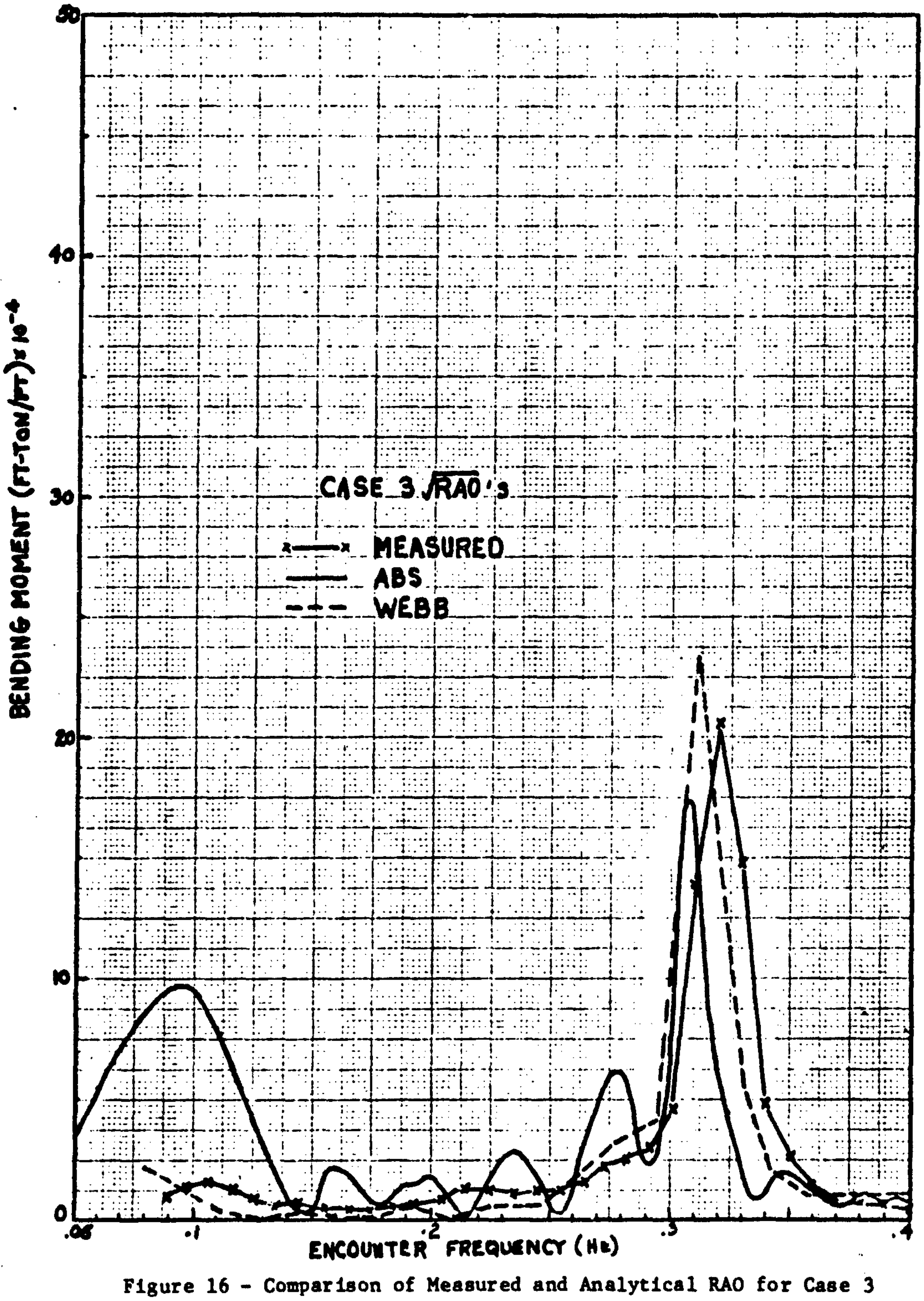


Figure 16 - Comparison of Measured and Analytical RAO for Case 3

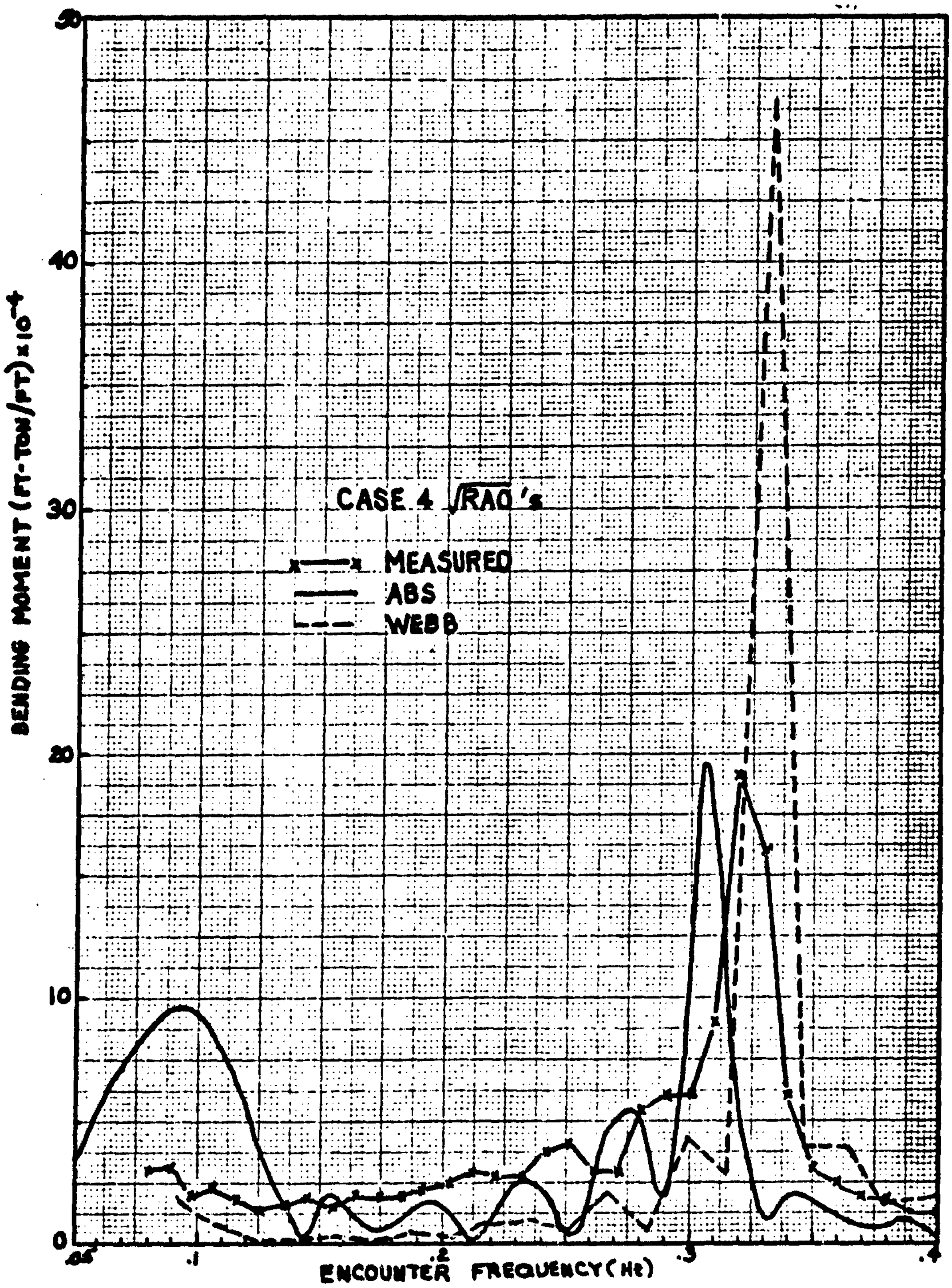


Figure 17 - Comparison of Measured and Analytical RAO for Case 4

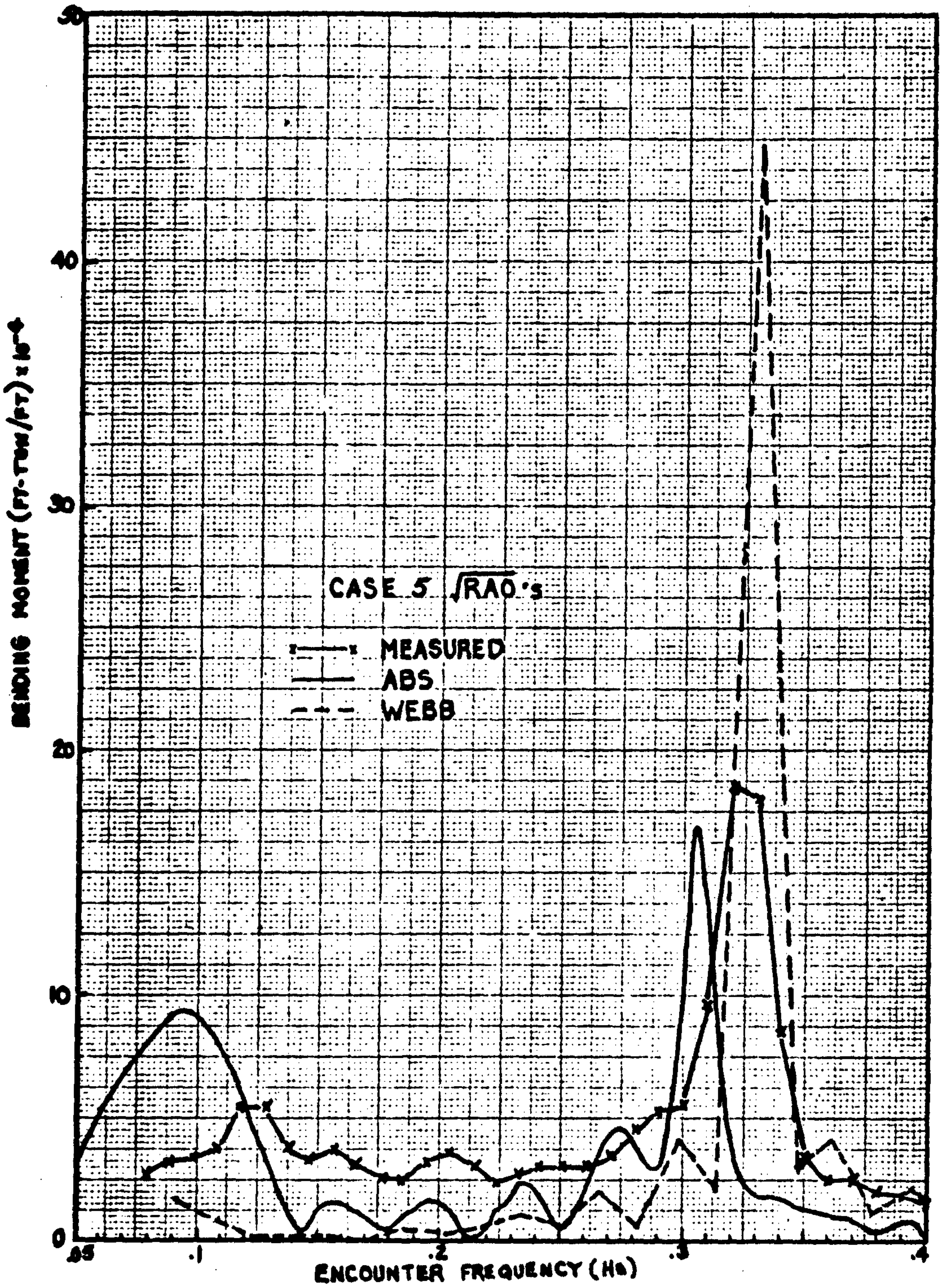


Figure 18 - Comparison of Measured and Analytical RAO for Case 5

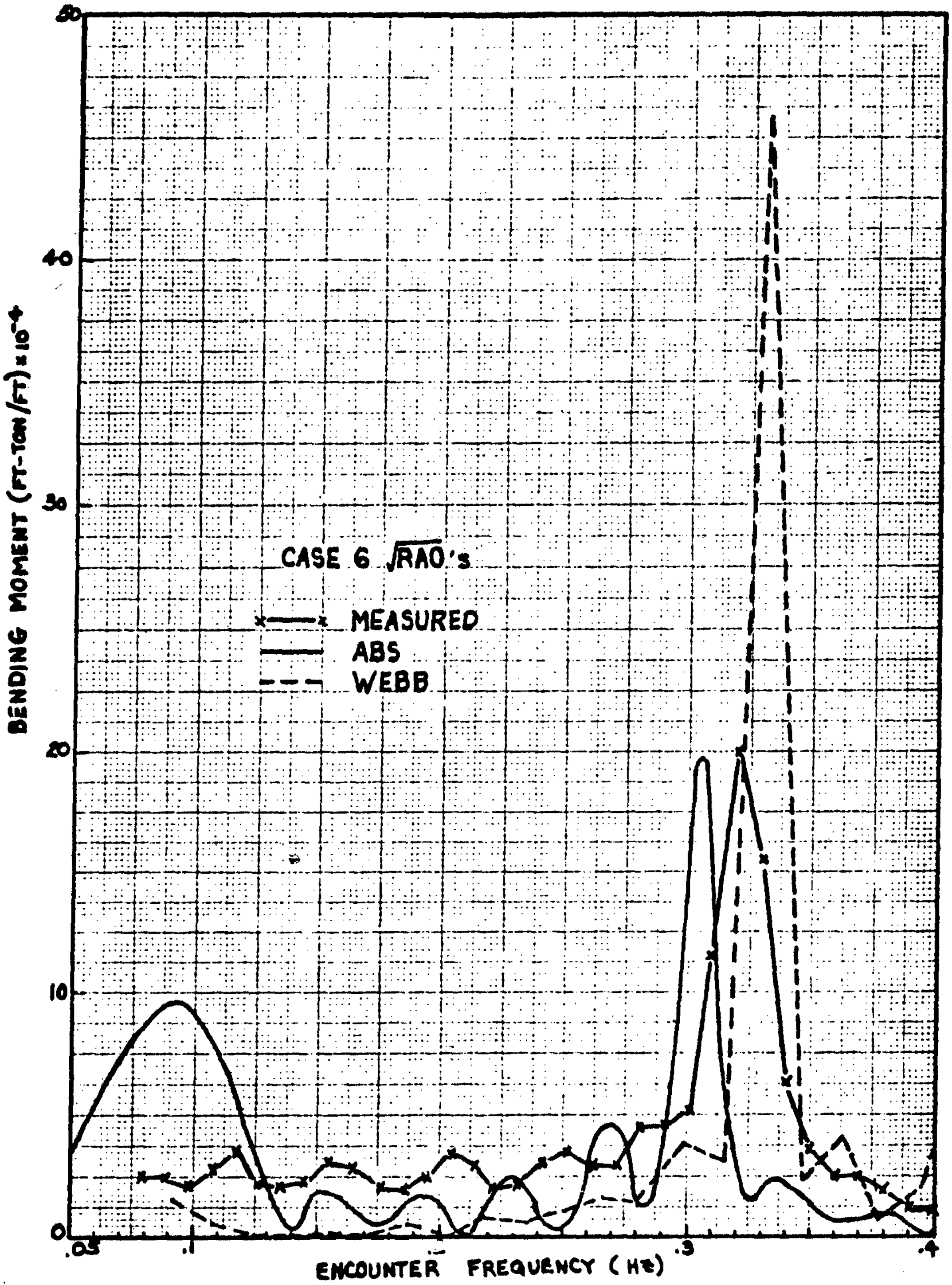


Figure 19 - Comparison of Measured and Analytical RAO for Case 6

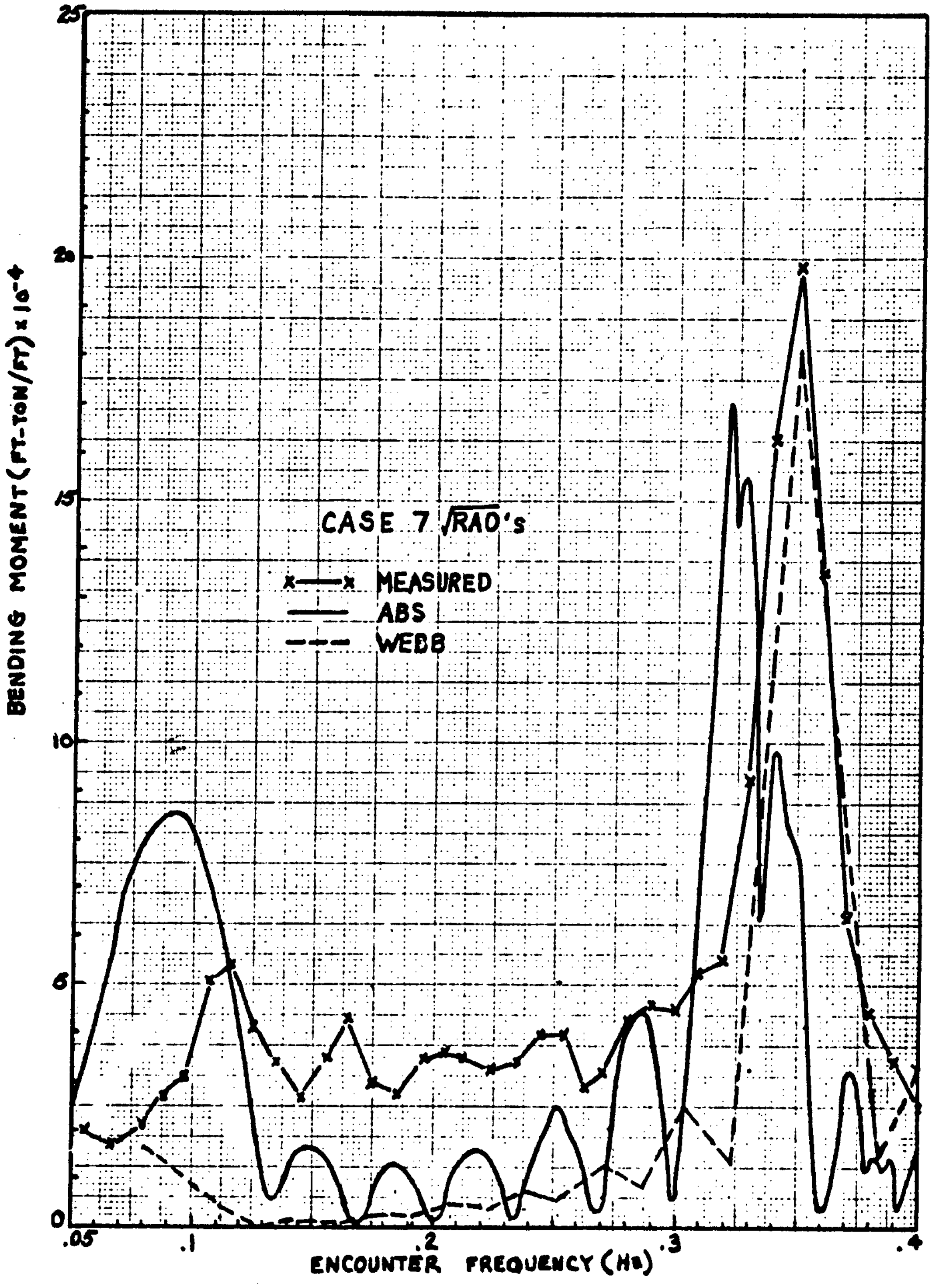


Figure 20 - Comparison of Measured and Analytical RAO for Case 7

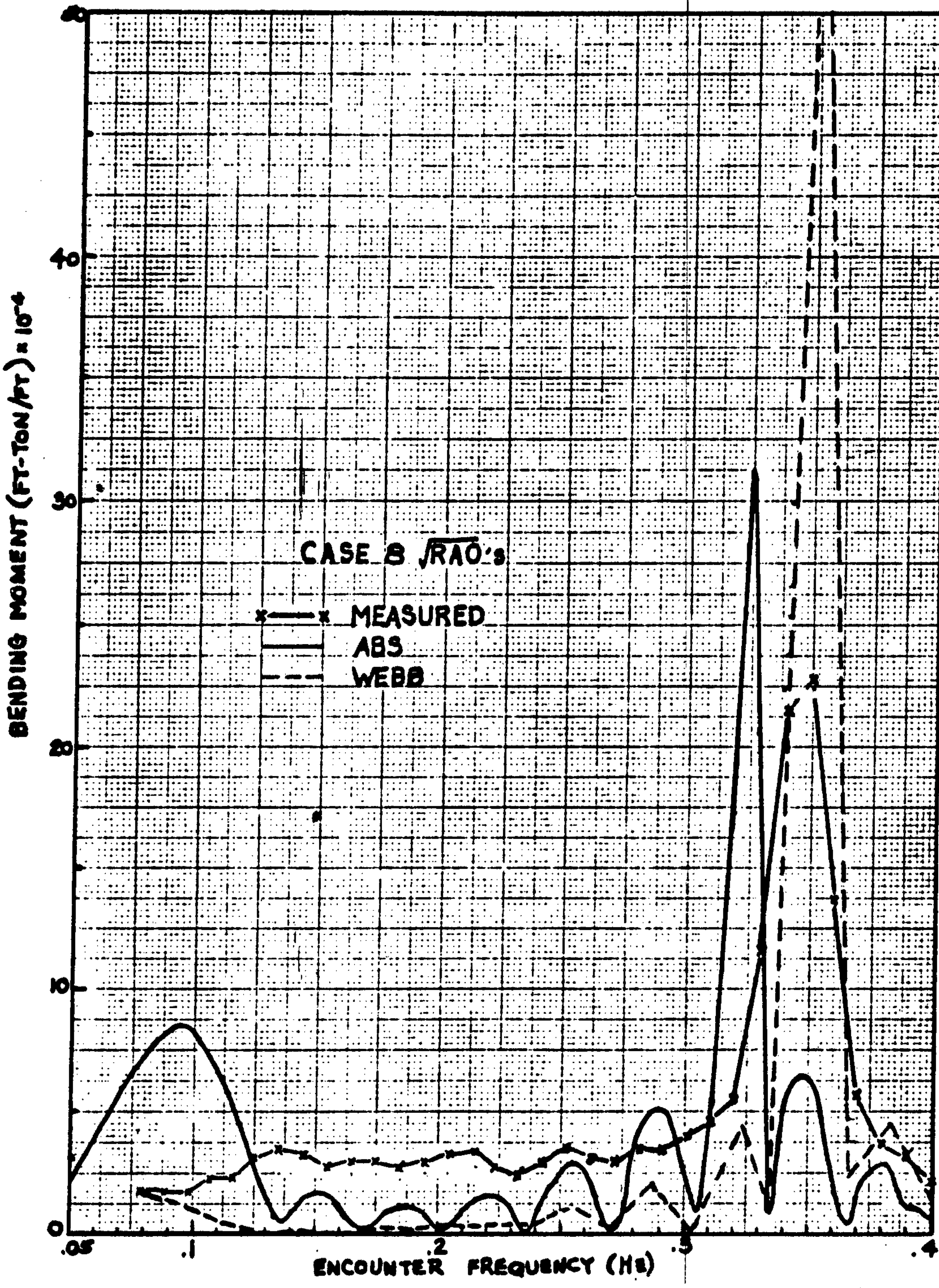


Figure 21 - Comparison of Measured and Analytical RAO for Case 8

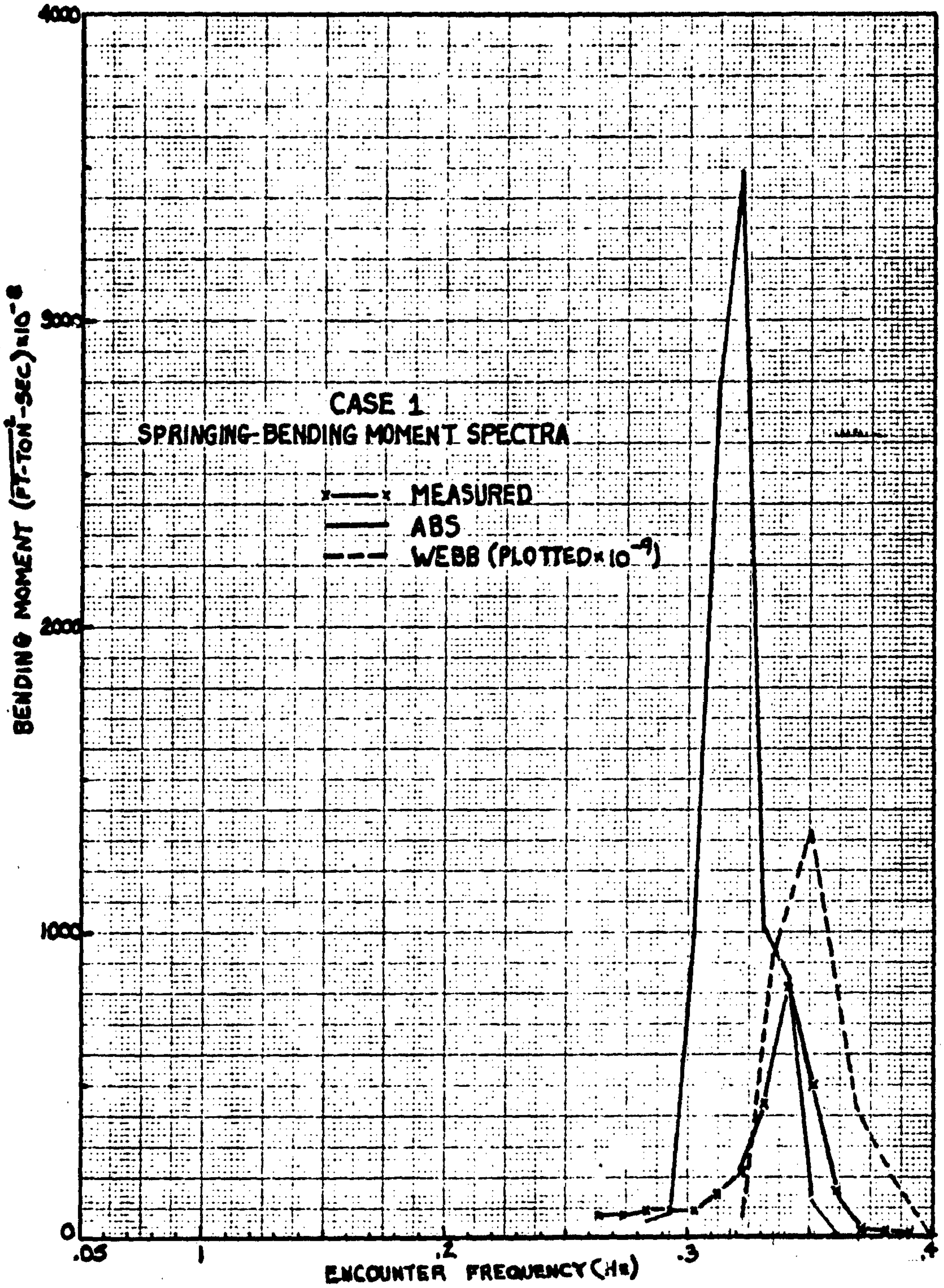


Figure 22 - Measured and Analytical Bending Moment Spectra for Case 1

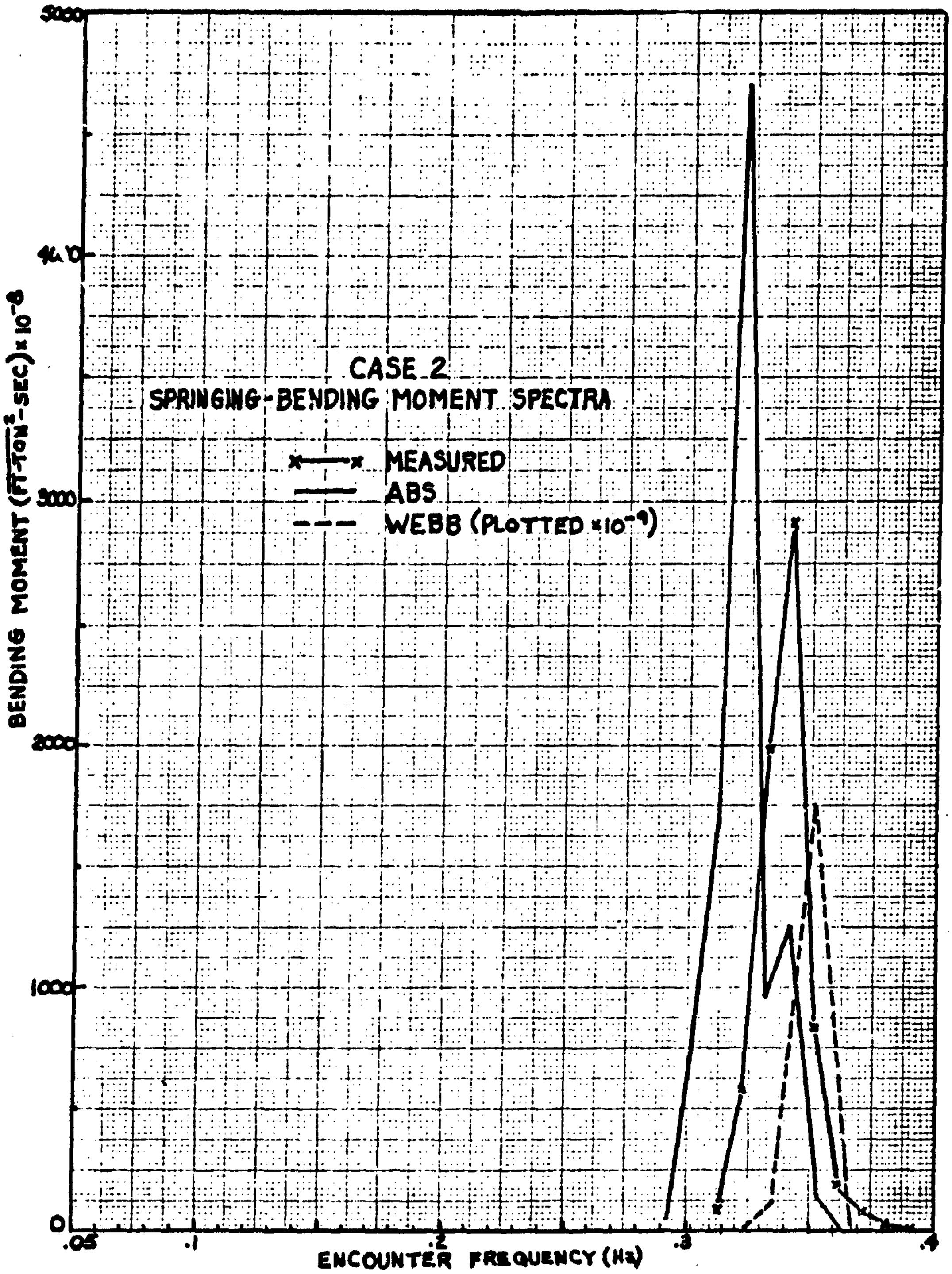


Figure 23 - Measured and Analytical Bending Moment Spectra for Case 2

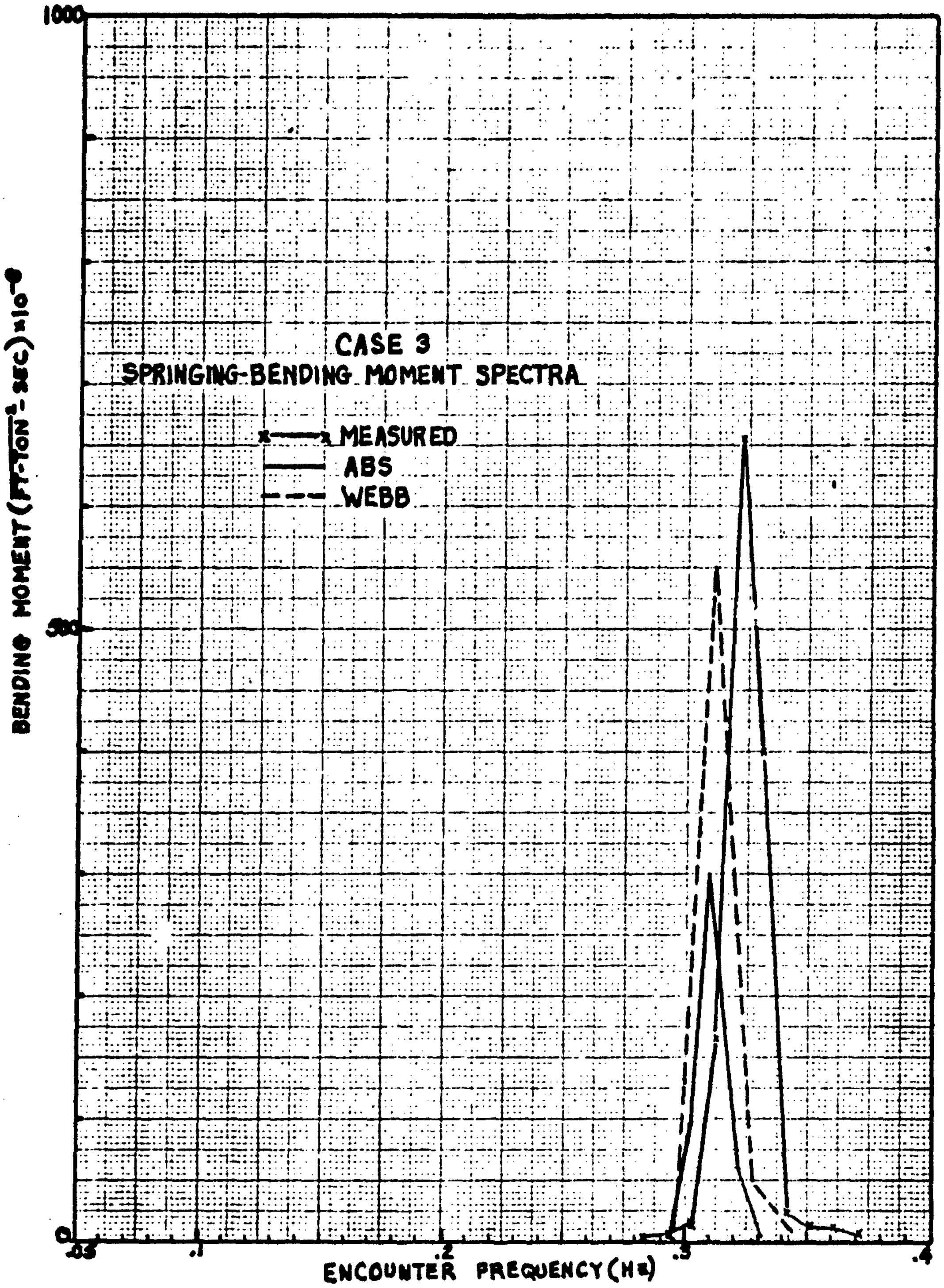


Figure 24 - Measured and Analytical Bending Moment Spectra for Case 3

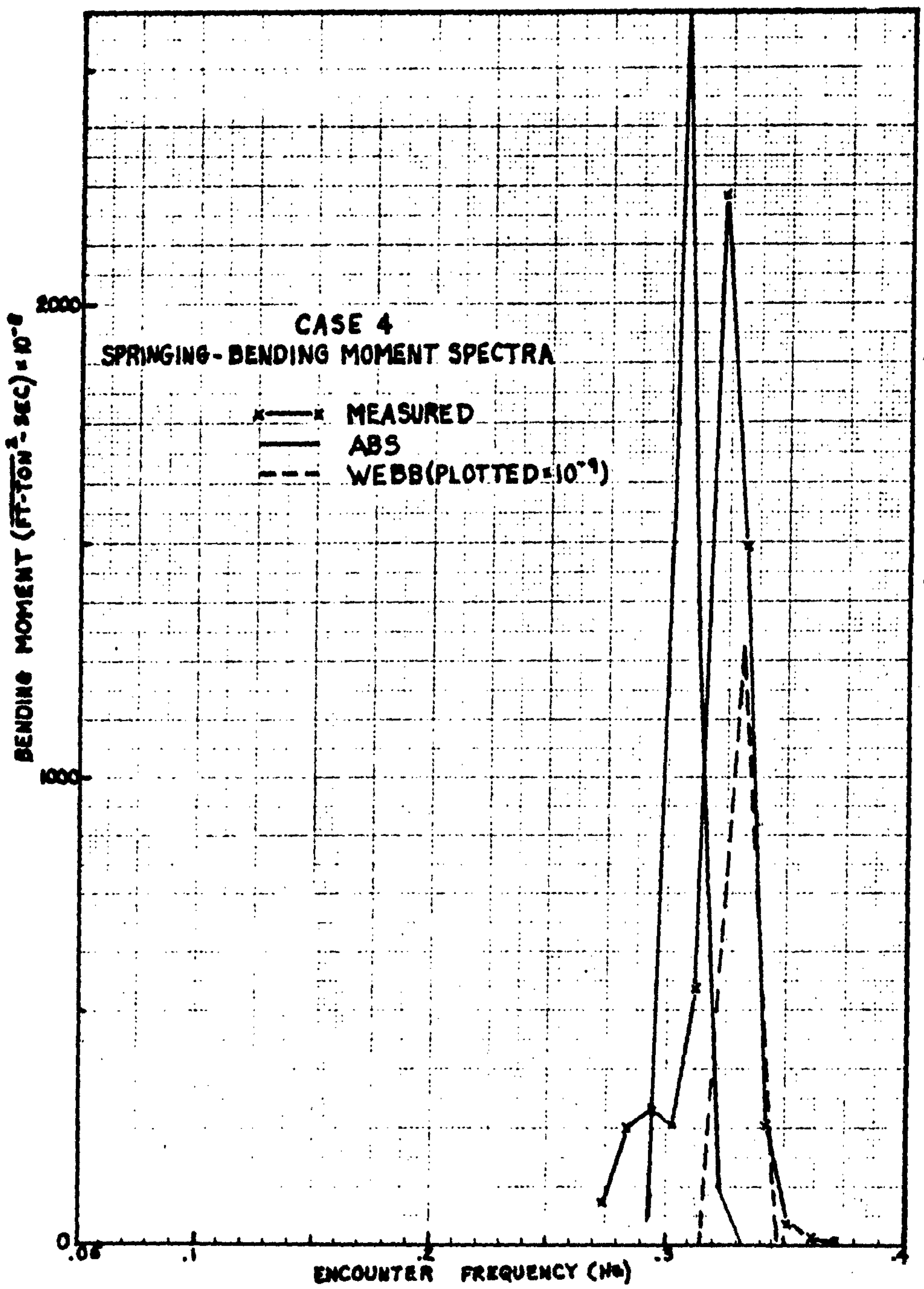


Figure 25 - Measured and Analytical Bending Moment Spectra for Case 4

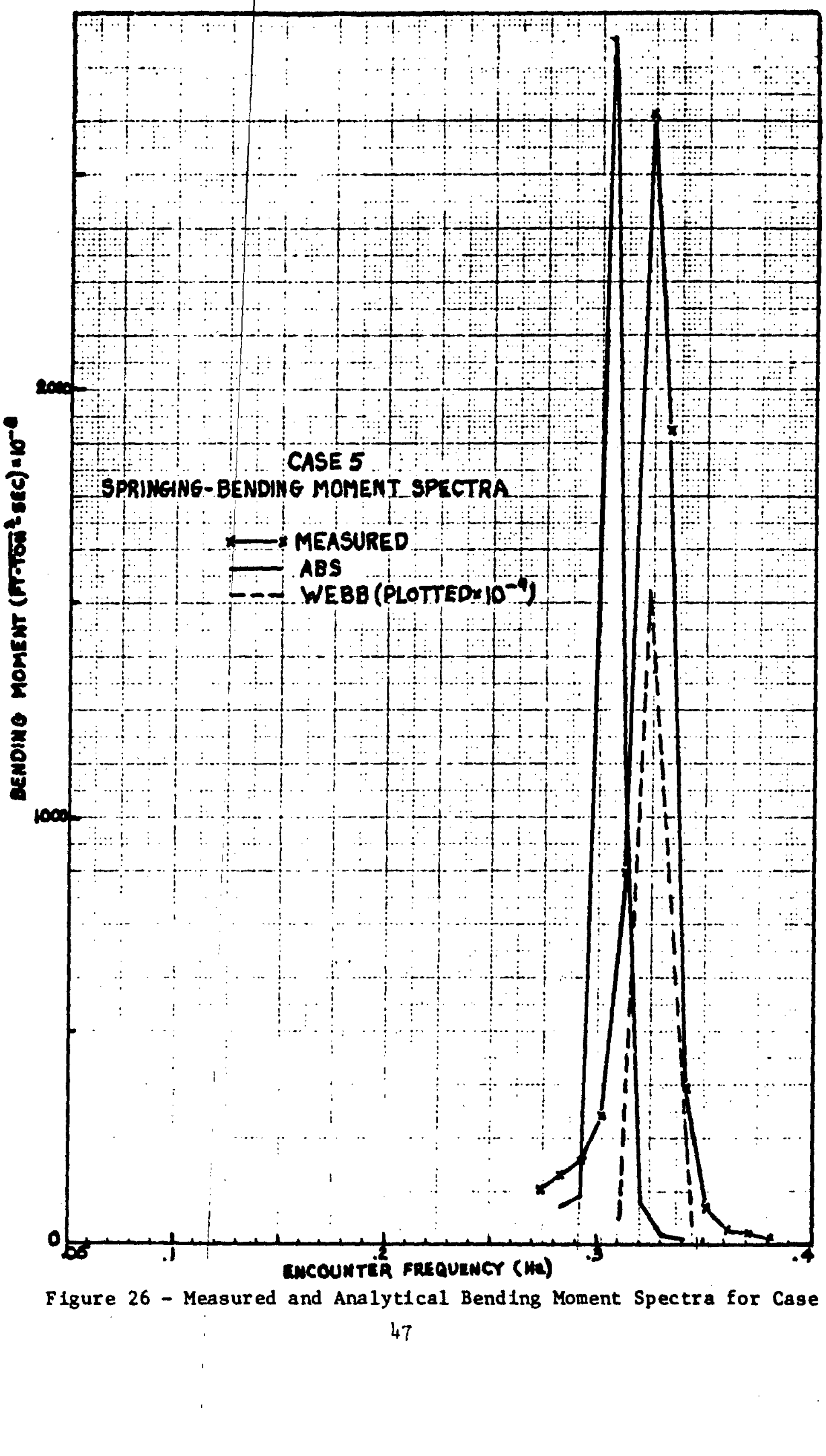


Figure 26 - Measured and Analytical Bending Moment Spectra for Case 5

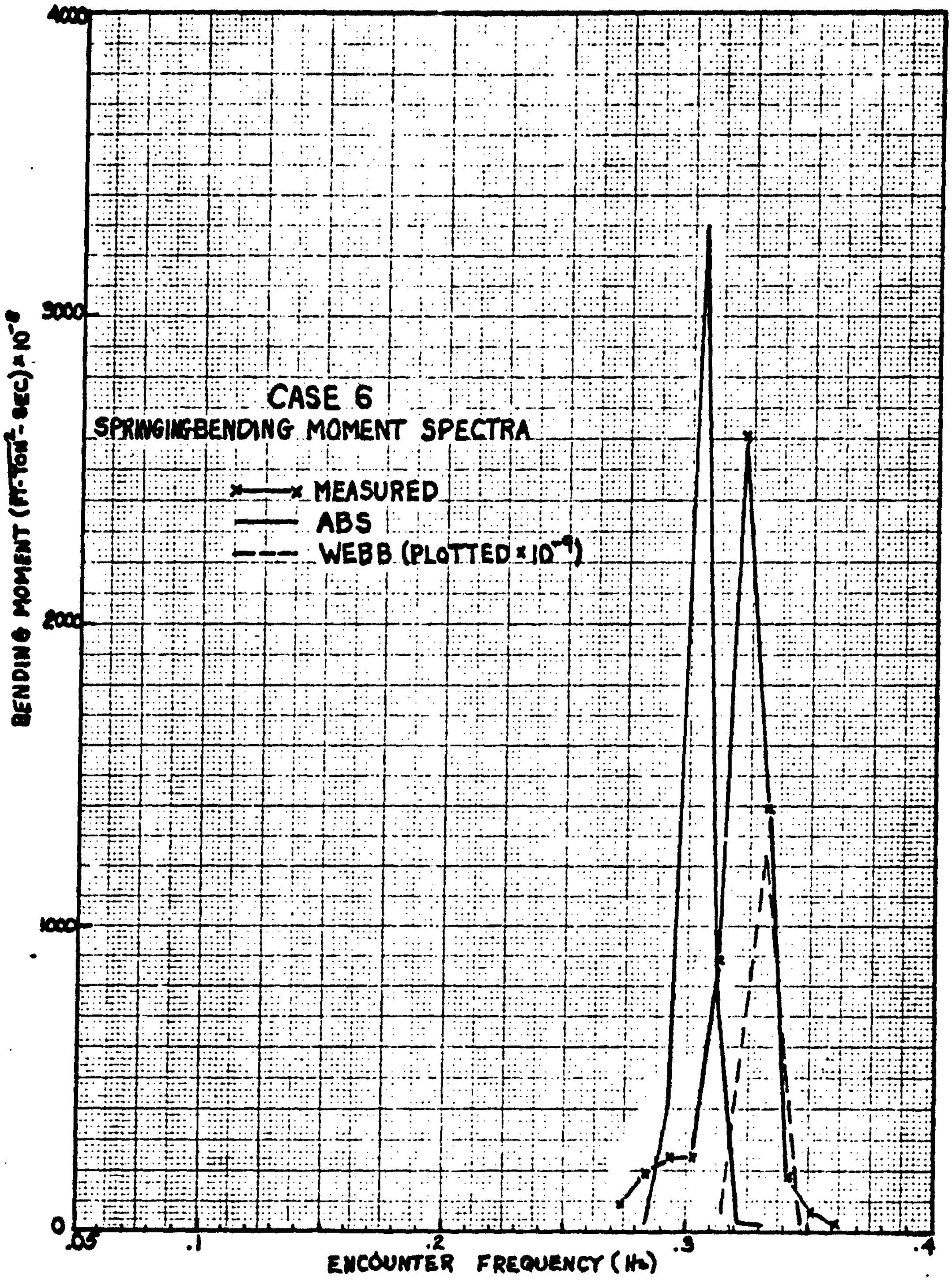


Figure 27 - Measured and Analytical Bending Moment Spectra for Case 6

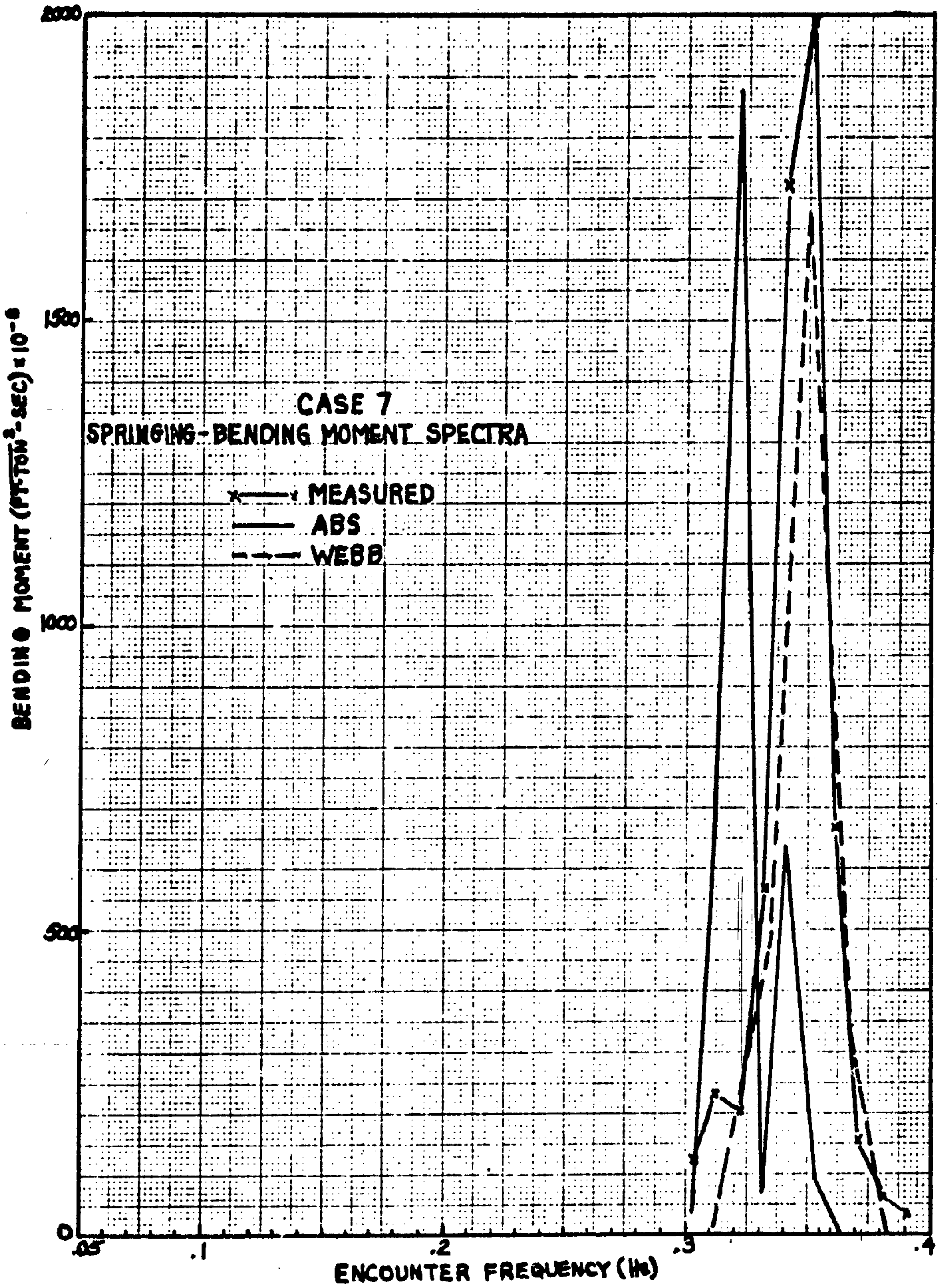


Figure 28 - Measured and Analytical Bending Moment Spectra for Case 7

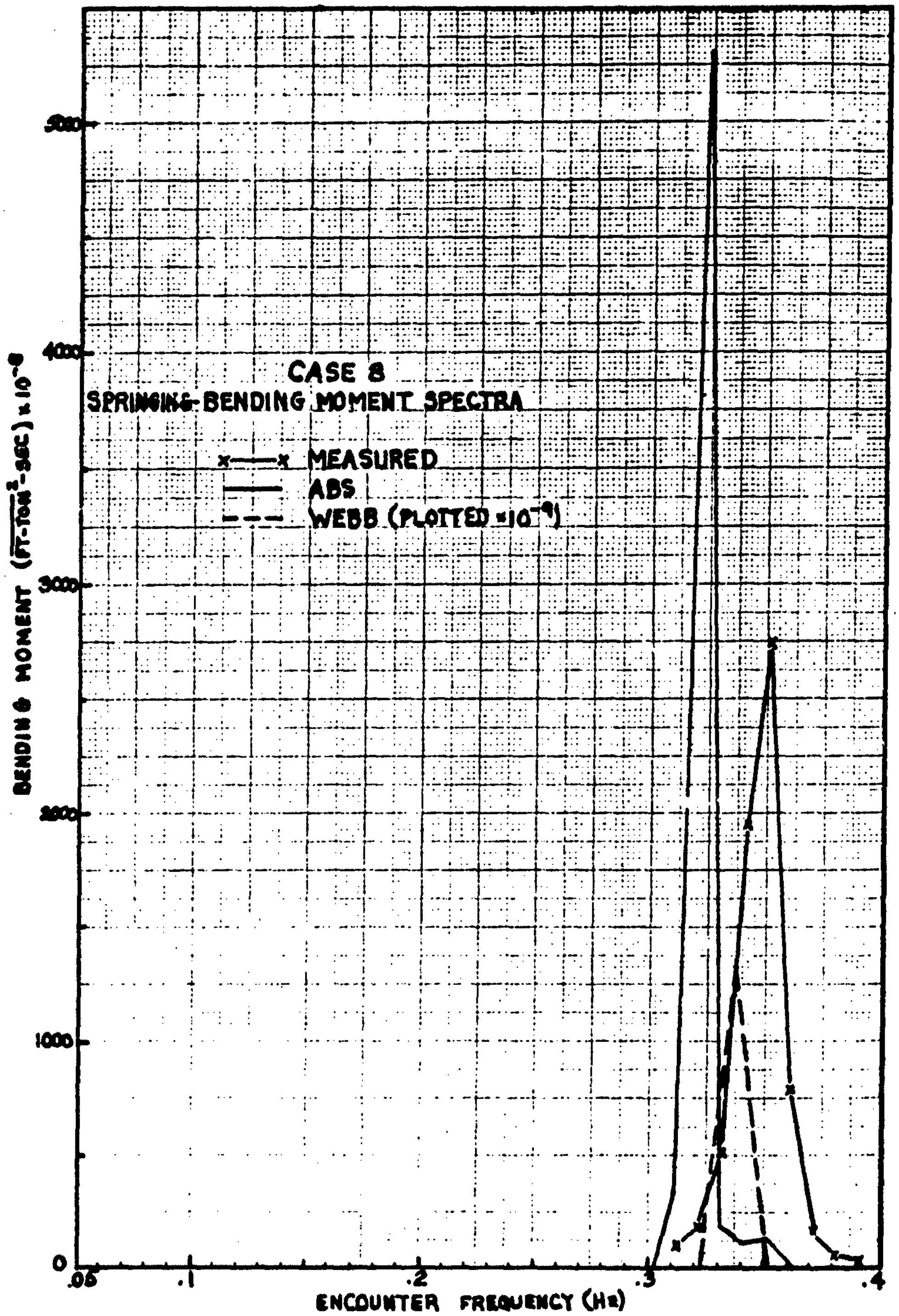


Figure 29 - Measured and Analytical Bending Moment Spectra for Case 8

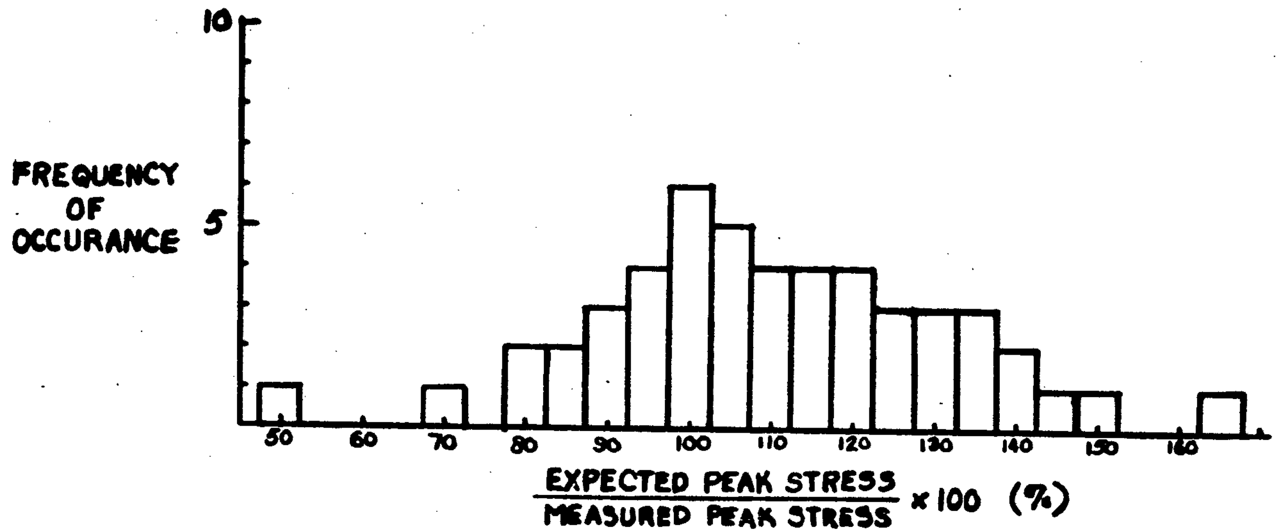


Figure 30 - Ratio of Expected to Measured Peak Bending Stress Versus Frequence of Occurence

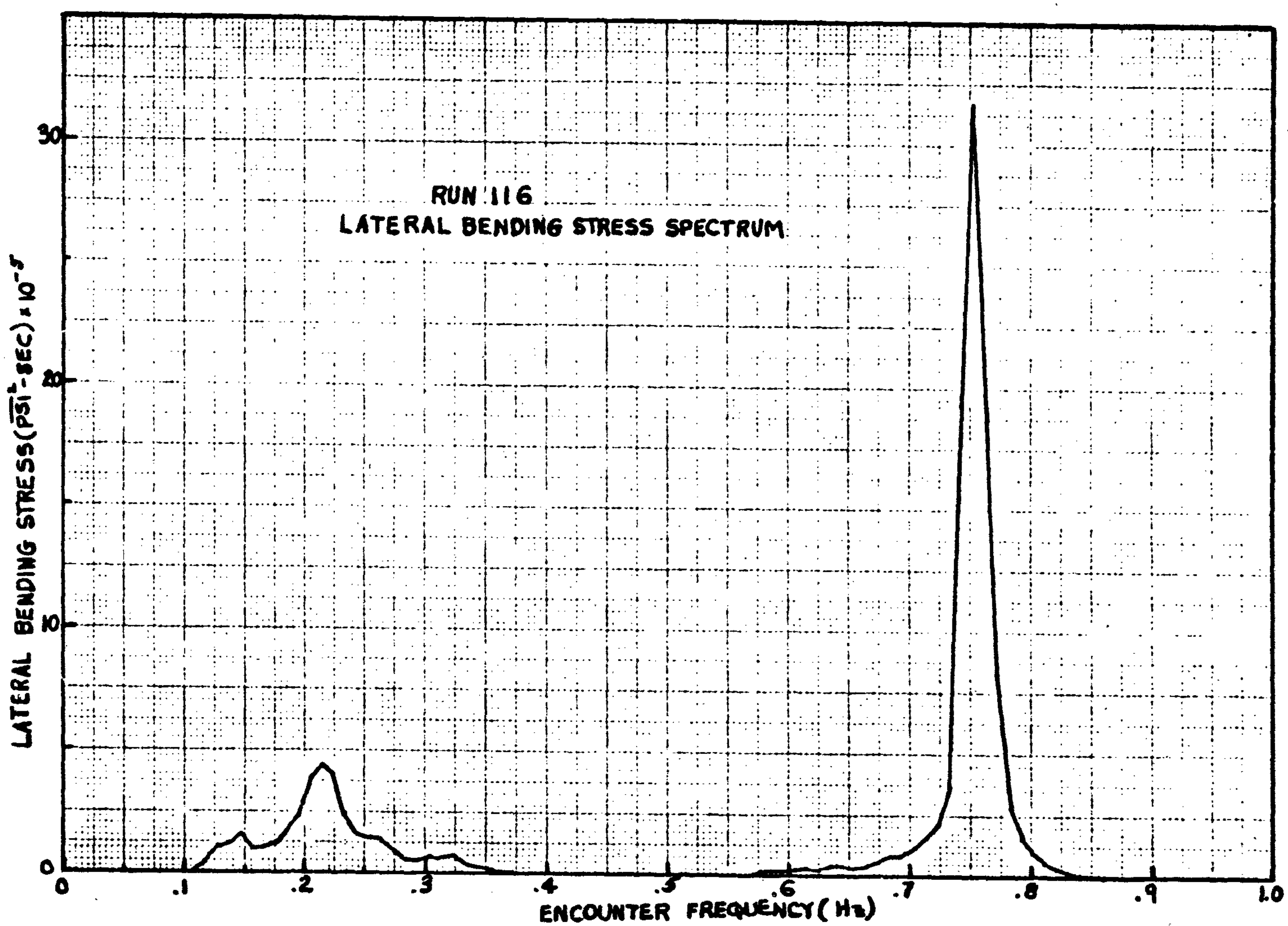


Figure 31 - Lateral Bending Stress Spectrum for Bow Sea Heading

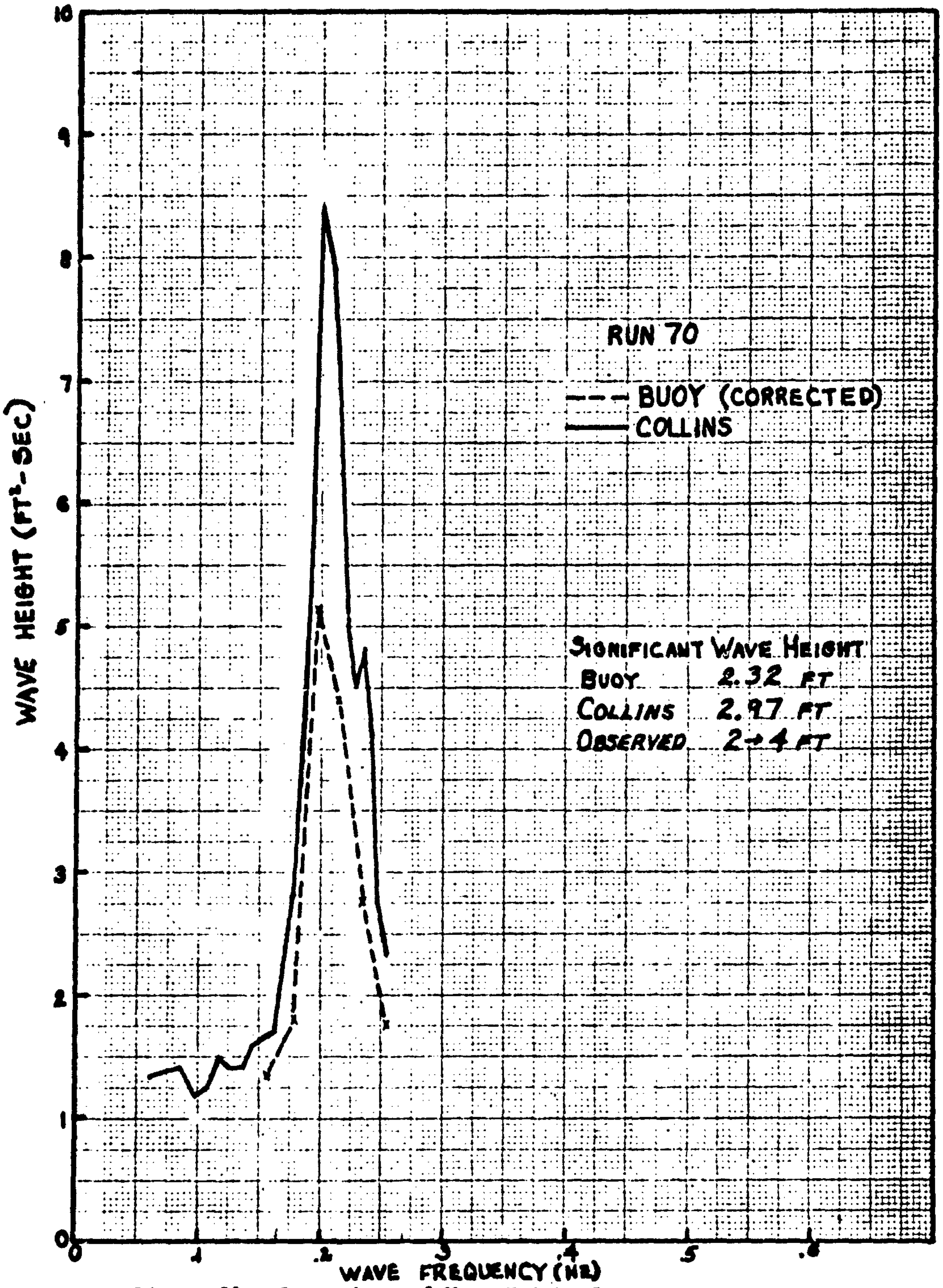


Figure 32 - Comparison of Wave Height Spectra Calculated from Collins Radar and Wave Rider Buoy for Run 70

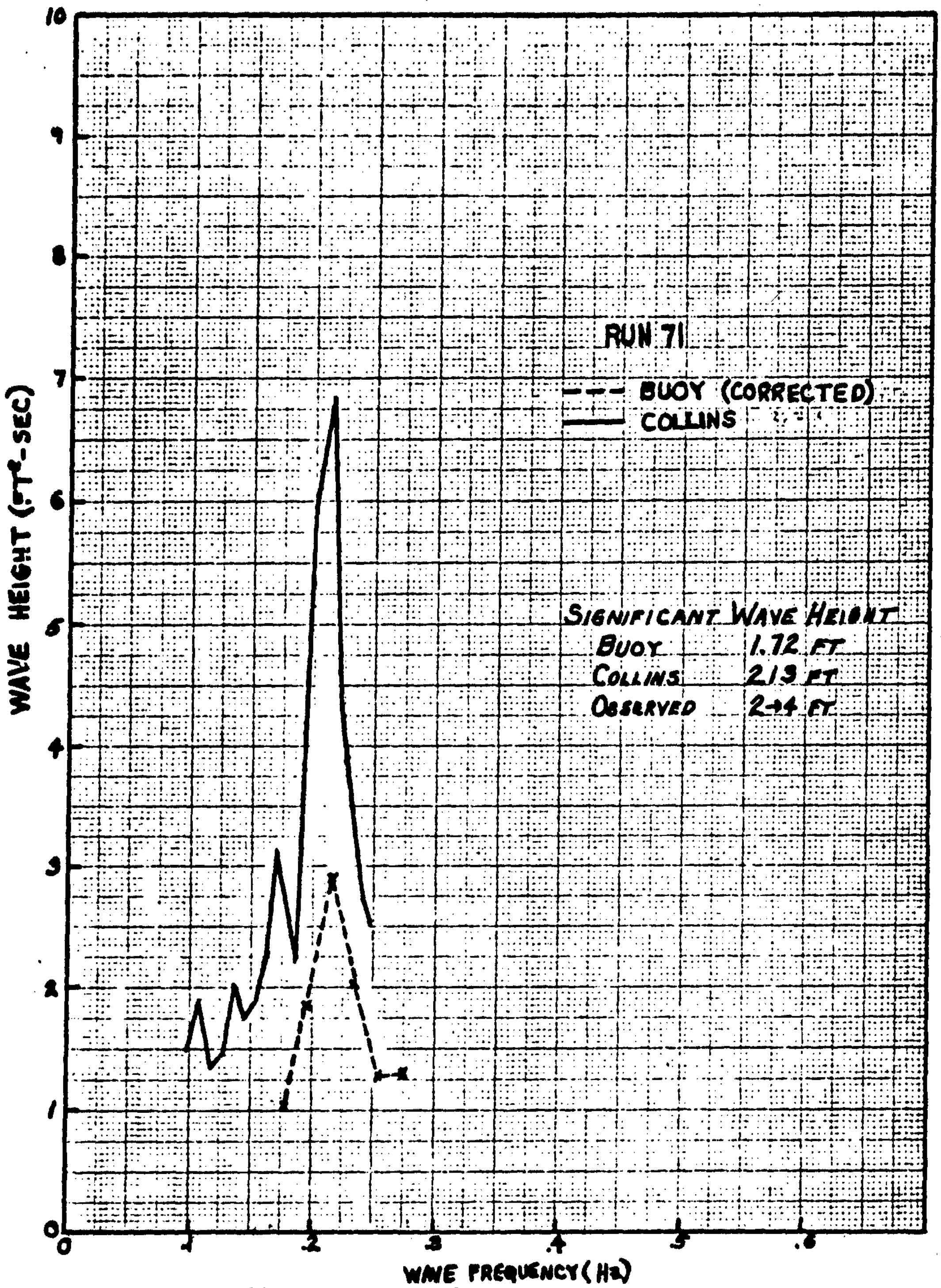


Figure 33 - Comparison of Wave Height Spectra Calculated from Collins Radar and Wave Rider Buoy for Run 71

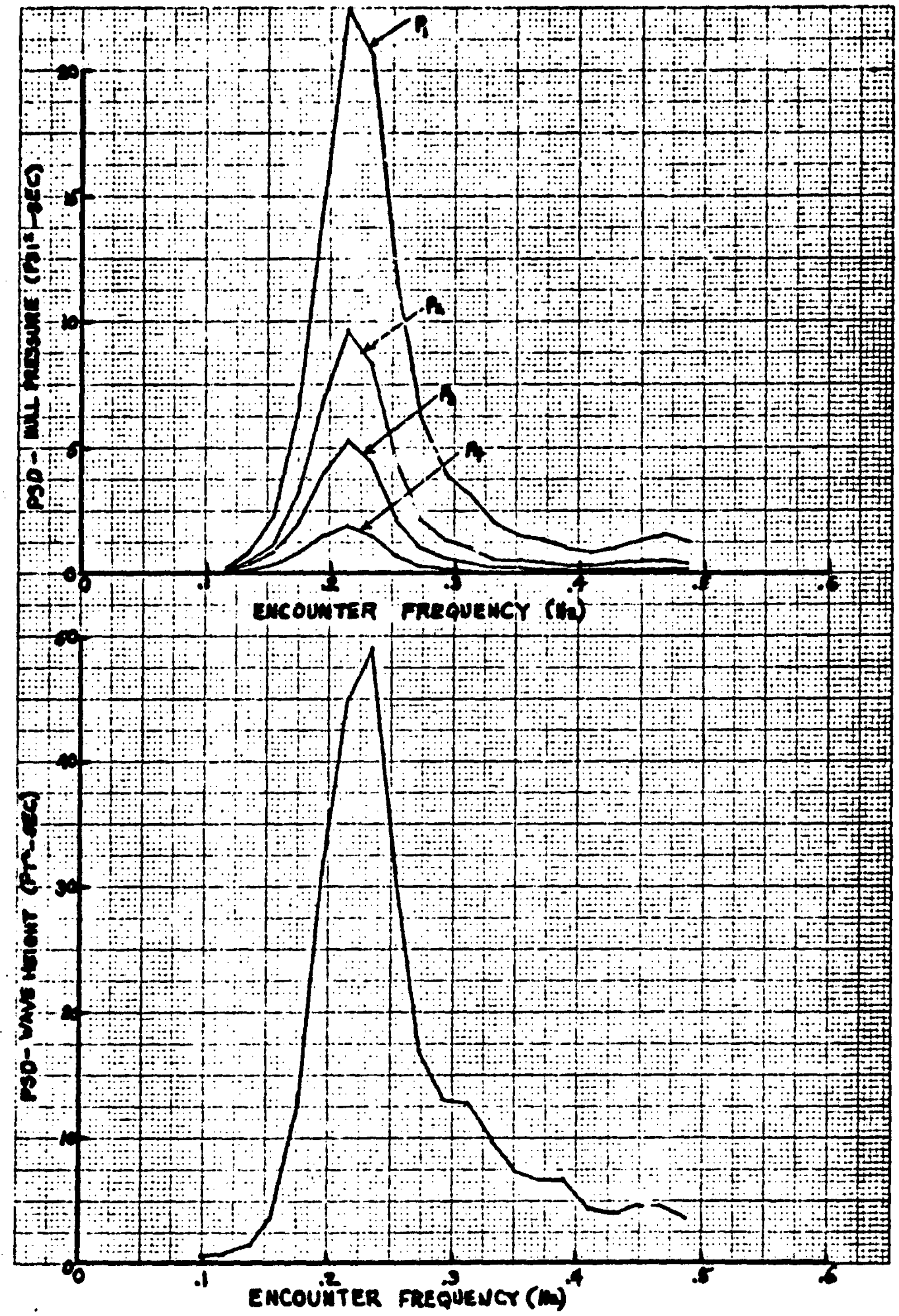


Figure 34 - Pressure and Wave Spectra for Run 77

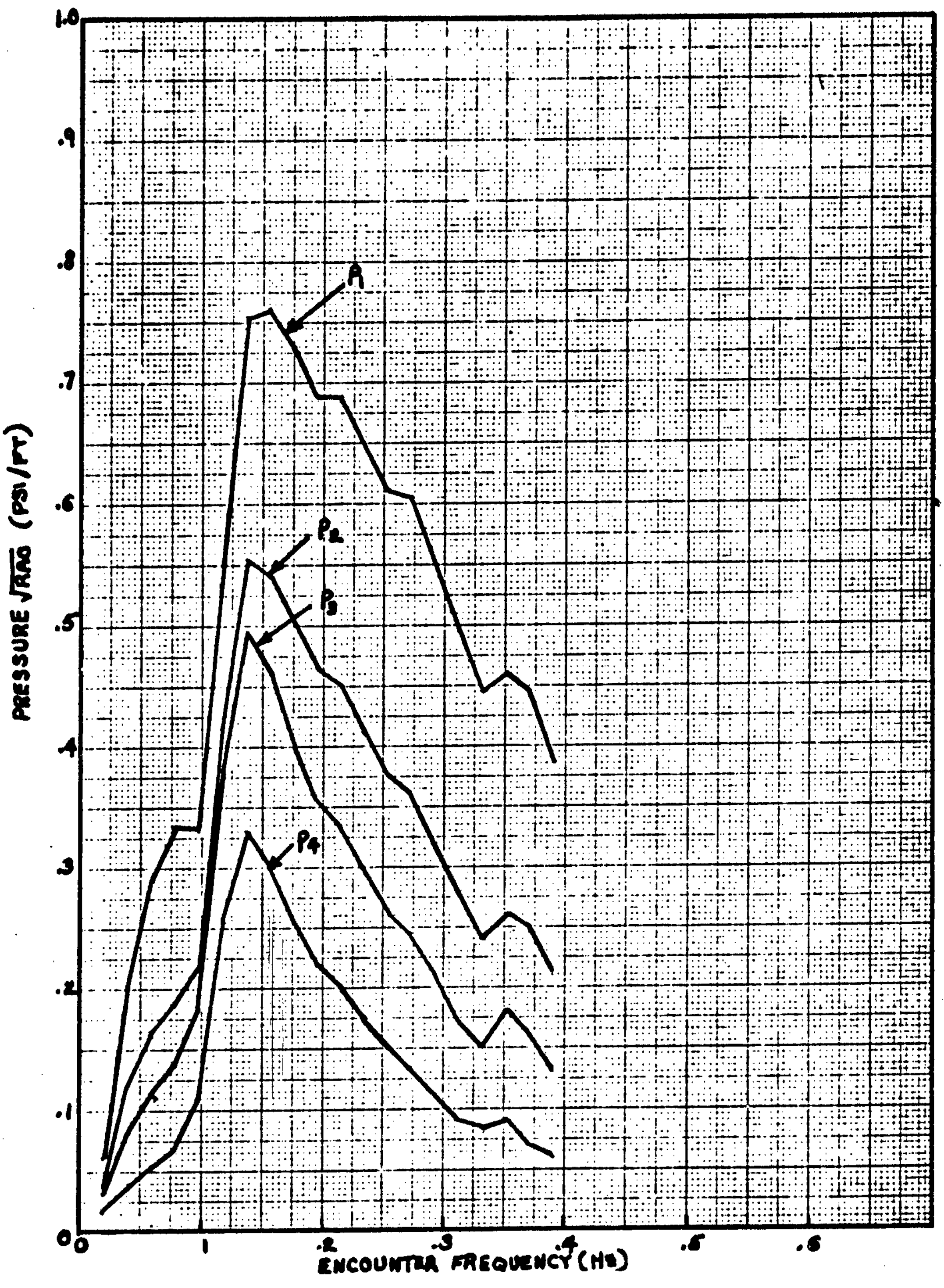


Figure 35 - Pressure Gage Response Operators for Run 77

TABLE 1 - MEASURANDS FOR M/V S.J. CORT FULL SCALE TRIALS

1. MICRO-WAVE RADAR*
2. COLLINS RADAR*
3. BOW VERTICAL ACCELERATION (AT COLLINS)*
4. BOW HORIZONTAL ACCELERATION (AT COLLINS)*
5. BOW VERTICAL ACCELERATION (AT MICRO-WAVE)*
6. BOW HORIZONTAL ACCELERATION (AT MICRO-WAVE)*
7. MIDSHIP DECK VERTICAL BENDING STRESS (COMBINED)
8. MIDSHIP DECK VERTICAL BENDING STRESS (WAVE INDUCED)
9. MIDSHIP DECK VERTICAL BENDING STRESS (SPRINGING)
10. MIDSHIP BOTTOM VERTICAL BENDING STRESS (COMBINED)
11. MIDSHIP LATERAL BENDING STRESS
12. MIDSHIP TORSIONAL STRESS
13. ROLL
14. PITCH
15. HEAVE ACCELERATION

16. → 20. PRESSURES AT FRAME 9/10

21. → 25. PRESSURES AT FRAME 20/21

26. → 30. PRESSURES AT FRAME 30/31

31. WAVE RIDER BUOY

* NRL MEASURANDS FROM WAVE MEASURING SYSTEM

TABLE 2 - INPUT PARAMETERS FOR ANALYTICAL RAO CALCULATIONS AND SIGNIFICANT WAVE HEIGHT MEASURED DURING EACH DATA RUN

Condition	Run Number	Speed (mph)	Draft			Ship-Wave Angle (degrees)	Measured Wave Height ($H_{1/3}$-feet)
			Fwd	Mid	Aft		
1	77	14.4	19'11"	20'7"	22'0"	6	9.6
2	81	14.4	19'11"	20'7"	22'0"	11	8.3
3	90	14.7	27'0"	27'0"	27'0"	6	3.7
4	119	14.2	27'0"	27'0"	27'0"	9	5.6
5	116	13.5	27'0"	27'0"	27'0"	23	8.5
6	117	13.5	27'0"	27'0"	27'0"	10	7.2
7	99	11.6	18'0"	19'11"	21'3"	0	6.0
8	101	11.6	19'11	20'7"	22'0"	20	8.6

TABLE 3 - PEAK TO PEAK SIGNIFICANT SPRINGING BENDING MOMENT FROM ANALYTICAL RAO's AND MEASURED SIGNIFICANT BENDING MOMENT FOR EIGHT CASES EXAMINED

CASE	Significant Springing Bending Moment (FT-TONx10^{-4})		
	Measured	ABS	WEBB
1	20.2	37.9	85.3
2	32.3	36.2	68.7
3	13.2	8.8	11.9
4	25.8	25.5	57.7
5	30.8	26.0	65.9
6	28.8	29.2	64.9
7	28.9	23.5	37.5
8	32.1	32.6	54.2

TABLE 4 - COMPARISON OF MEASURED AND PREDICTED PEAK BENDING STRESS

Run Number	Measured Peak Bending Stress (KPSI)	Predicted Peak Bending Stress Using Eqn (8) (KPSI)	Peak Predicted Divided By Measured Peak X100% (%)
27	3.84	2.77	72.0
28	3.57	3.24	90.8
29	2.48	2.36	95.0
30	.83	.86	103.7
32	2.64	2.43	92.1
35	2.92	3.18	108.9
37	2.97	2.87	96.7
38	3.74	3.88	103.9
39	5.36	6.96	129.8
40	6.27	6.22	99.2
41	5.52	6.62	120.0
42	4.21	5.01	118.8
43	7.00	5.60	79.0
45	4.74	4.51	95.2
46	.97	.89	91.2
50	5.38	5.85	108.7
52	4.87	5.18	106.3
53	5.56	5.57	100.1
54	4.38	3.77	86.2
64	3.03	3.43	114.5
66	1.05	1.15	109.0

TABLE 4 - (Continued) - COMPARISON OF MEASURED AND PREDICTED PEAK BENDING STRESS

Run Number	Measured Peak Bending Stress (KPSI)	Predicted Peak Bending Stress Using Eqn (8) (KPSI)	Peak Predicted Divided By Measured Peak X100% (%)
67	.61	.61	99.2
70	2.93	2.54	86.5
71	2.50	1.28	51.2
74	5.54	6.43	116.0
75	7.62	7.51	98.5
77	8.01	7.84	97.9
80	8.25	9.66	117.1
81	7.56	10.32	140.1
82	6.13	9.82	162.7
83	6.03	7.93	133.4
85	5.94	8.06	137.2
89	3.37	2.63	78.0
90	3.05	2.96	96.9
94	6.57	7.82	119.0
95	7.39	8.66	117.2
99	6.75	9.55	141.3
100	9.29	11.89	127.9
101	9.23	11.15	120.8
102	6.02	10.07	167.2
103	5.97	9.05	151.5
107	3.67	4.66	126.8

TABLE 4 - (Continued) - COMPARISON OF MEASURED AND PREDICTED PEAK BENDING STRESS

Run Number	Measured Peak Bending Stress (KPSI)	Predicted Peak Bending Stress Using Eqn (8) (KPSI)	Peak Predicted Divided By Measured Peak X100% (%)
110	5.68	6.16	108.4
111	5.42	6.75	123.4
112	6.80	7.29	107.1
113	8.41	12.13	144.2
114	8.71	10.74	132.5
115	8.21	10.59	123.8
116	8.56	11.12	136.6
117	9.09	9.44	103.7
119	8.13	8.66	106.4

TABLE 5 - PEAK SINGLE AMPLITUDE VERTICAL, LATERAL AND DECK EDGE BENDING STRESSES FOR BOW SEA HEADINGS EXAMINED

Run	Peak Vertical Bending Stress (PSI x 10^{-2})	Peak Lateral Bending Stress (PSI x 10^{-2})	Peak Deck Edge Bending Stress (PSI x 10^{-2})
29	24.8	8.4	27.8
30	8.3	4.2	9.7
38	37.4	11.2	39.0
39	53.6	11.9	58.4
43	70.1	15.6	75.0
45	47.2	19.2	55.3
100	92.9	7.9	93.0
101	92.3	9.4	93.0
103	59.8	10.6	61.3
111	54.7	20.1	63.2
112	68.0	15.7	75.9
114	87.1	16.9	87.5
115	82.1	12.3	91.5
116	81.6	15.5	85.7

TABLE 6 - MAXIMUM SINGLE AMPLITUDE MIDSHIP TORSIONAL STRESSES FOR BOW SEA RUNS

Run	Maximum Torsional Stress (PSI x 10^{-2})
29	1.04
30	.21
38	.85
39	1.17
43	1.17
45	1.32
100	1.74
101	1.59
103	1.34
111	1.78
112	1.78
114	1.48
115	1.34
116	1.43

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APPENDIX A

TRANSDUCER CALIBRATIONS AND CALCULATIONS OF TRANSDUCER SENSITIVITIES

The total instrumentation package for the CORT full scale data collection program consisted of 32 individual measurements of wave height, stress, motion and pressure (Table 1). Each of these measurands output an electrical direct current analog signal to the PDP 11/03 analog to digital (A/D) converter for subsequent storage of these digitized electrical signals on magnetic tape. The development of the relationships for converting these electrical voltages to engineering units (EU) follows. The computer system sensitivity (EU/count) can be arrived at by dividing the voltage sensitivity (EU/volt) by 400 which is the number of counts per volt.

STRAIN GAGES

Four independent measurements of strain were made on the CORT. All measurements were made at the CORT midship section. Measurements included stresses induced by vertical bending, athwartship bending and hull girder torsion. Locations of the gages at the midship section were given in Figure 3 of the text. The main deck bending and lateral bending gages were installed for previous data collection on the CORT. These gages were mounted in a dyadic configuration on the ship's hull plating with the bridge configurations indicated in Figure A1. The existing hull bottom vertical bending gage from previous data collection on CORT exhibited a low resistance to ground and drift and was subsequently replaced at the location shown in Figure 3 of the text. The bridge configurations for the bottom bending stress and torsional shear stress measurements are given in Figure A2.

Calibration of the stress measuring channels was accomplished by connecting a calibration resistor across one leg of the Wheatstone bridge. Since long lengths of cable where run between the gage and instrumentation, no matter where

this shunt calibration is performed (at the gage site or at the instrumentation), an error is introduced. If the shunt resistor is applied at the instrumentation, the signal due to connecting the shunt resistor is increased by $2R_L/R$, where R is the nominal resistance of each leg of the bridge and R_L is the resistance of the lead wire from the gage to the instrumentation. Additionally, the output signal to the instrument caused by strain in any gage is attenuated by $2R_L/R$. These conditions produce a calibration signal which is in error to the strain signal by a factor of $4R_L/R$. A correction for this error can be made by multiplying the nominal strain (or stress) that the nominal shunt calibration (performed at the instrumentation) represents by $(1+4R_L/R)$. Similarly, a sensitivity in terms of stress per unit output voltage is corrected for lead wire resistance by calculating the apparent stress that the shunt calibration represents, multiplying the nominal stress by $1+4R_L/R$, and dividing by the output voltage obtained when the shunt is performed at the instrumentation. This type of error is inherent in any strain gage or transducer where a simple Wheatstone bridge is employed to measure a particular quantity and this correction was accounted for. This correction was applied to all strain gages and pressure gage channels in arriving at a sensitivity for them.

Onboard checks were made of the main deck bending stress data by obtaining the ships neutral axis from time histories of the main deck and keel vertical bending gages. Initially, these values agreed with section property calculations within 5%. Subsequent analysis of the bottom bending bridge raised questions about its reliability and are discussed later.

The main deck bending signal was filtered to isolate the wave induced and springing components of the combined signal. These split signals were continuously monitored to assess the relative magnitudes of the wave induced and springing

components of the main deck bending stress and to aid in the determination of when to take data runs. A block diagram of the stress monitor is given in Figure A3.

The wave induced component was provided by low pass filtering the combined signal at a cut-off frequency of .2HZ, and the springing component was produced by high pass filtering the combined signal at a cut-off frequency of .25HZ. Each of the two filtered channels employed two Krohnhite variable filters which were cascaded to produce a sharp roll of 96 db/octave.

The filters were calibrated in the lab, at DTNSRDC, with a function generator to generate the phase delay and signal attenuation characteristics shown in Figures A4 and A5. Additionally, all stress channels were low pass filtered at 10 Hertz to remove any high frequency noise in the signal. The filters used for this were 2-pole Butterwoth with 12 db/octave rolloff. The calculations for shunt resistance simulated stress, lead wire correction and stress/voltage sensitivity for all the stress measuring channels follows the text of this appendix.

PRESSURE GAGES

Each pressure gage was calibrated at DTNSRDC in a dead weight tester over its operating pressure range. The operating pressure ranges for each gage is given in Table A1. The result of these calibrations is a linear relationship between applied pressure and transducer output voltage. Each pressure gage was also shunt calibrated in the laboratory with a known resistor and essentially zero lead wire resistance. This shunt produced an electrical offset in the pressure gage bridge which could then be thought of as a simulated pressure in terms of the gage's pressure/voltage sensitivity. The same shunt calibration resistor was applied at the gage site and the voltage offset recorded at the instrumentation after the gages were installed on CORT. In this manner, the lead

reistance of the cabling was established and accounted for. The onboard sensitivity of each pressure gage, corrected for lead wire resistance and the laboratory calibrated sensitivity values, for all pressure gages is given in Table A1. It is worth noting that each pressure gage was balanced to zero volts (pressure) when the ship was stationary and each gage had a finite static pressure head on it. Thus all pressures recorded reflect fluctuations in pressure about this static pressure head and the actual pressure on the hull would be the pressure fluctuation plus the static head.

SHIP MOTIONS

The ship motions recorded consisted of amidship measurements of pitch, roll and heave acceleration and bow measurements of lateral and vertical accelerations. The pitch and roll gyro was calibrated in the lab at DTNSRDC by tilting the gyro at various angles and measuring the output voltage. This calibration was also performed on board to take into account the lead wire resistance on this measurement and the shipboard cal was used for data analysis. The heave accelerometer was calibrated by turning the accelerometer 180^{o} simulating a 2g downward acceleration and recording the output voltage. The results of these calibrations are given in Table A2.

The lateral and vertical accelerations at the ship's bow were part of the NRL wave measuring systems installed on CORT. Lateral and vertical accelerometers were located at each wave measuring device. Acceleration to voltage sensitivities were supplied by NRL for these measurements. On board calibrations of these measurands were performed by tilting the accelerometers at various angles to assure that these measurands were still functioning as calibrated in the NRL lab. A listing of the NRL and Collins radar accelerometers and their sense is given in

Table A3. Additionally, all NRL installed acceleration signals were low pass filtered at 4 Hertz using a 4-pole Bessel filter.

COLLINS RADAR

Shipboard calibrations of the Collins radar altimeter were performed regularly to assure that this system was functioning as set up. The calibration consisted of tilting the horns vertically to aim them directly at the water surface and taking a voltage reading. The boom holding the horns was then swung in and aimed at the ship deck and another voltage reading taken. The distance from the ship's deck to its baseline was known and by subtracting the distance from the ship waterline to ship baseline (ship draft), the distance from the deck to the waterline established. Dividing the change in distance from each measurement, by the change in voltage, the sensitivity of the Collins radar (ft/volt) was checked. A typical calculation is given in Figure A6. This calibration was performed when the ship was in port or in the Soo Locks due to the need for calm conditions to achieve this calibration.

WAVE BUOY CALIBRATION

The wave rider buoys and receiver employed in these trials were supplied by Teledyne Engineering Services under USCG contract. The output voltage to acceleration sensitivity supplied with the buoys was 15 volts/g of acceleration. Static on board calibration of the buoys was achieved by tilting the buoys at a known angle, determining the acceleration from this angular tilting and recording the output voltage. Results of these calibrations indicated output voltage to acceleration sensitivities of 15.3 volts/g and 16 volts/g for buoys #1 and #2 respectively. Due to some uncertainty in the angle measurement during these cals a voltage sensitivity of 15.0 volts/g was employed for the trials. After analyzing

the buoy data and observing a large discrepancy between the buoy and Collins Radar wave spectra, a dynamic calibration of the buoys was suggested. This calibration was carried out by Messrs. M. Noll and D. Walden in the NOAA wave buoy calibrator at the Washington Navy Yard. The dynamic calibration showed the buoy/receiver system to have an increasing sensitivity with increasing acceleration frequency. The results of this calibration are given in Figure A7 and were applied to the buoy spectra given in the text.

ANOMALOUS BEHAVIOR OF BOTTOM BENDING BRIDGE

Initial onboard checks on the ratio of measured main deck to bottom bending stress were found to be in the range of 1.10 to 1.20 (1.15 was expected based on CORT section properties). Daily shunt calibrations and resistance to ground checks indicated the bridges were functioning normally and calibration sensitivities were never changed. Post trials analysis of the data shows that the ratio of the main deck RMS stress to bottom bending RMS stress to be above the expected range beginning in early November. This ratio grew larger (although not constantly) as trials progressed. Since the main deck stress/wave height RAO's remained fairly constant from run to run on any given day, whereas the ratio of bottom to deck stress ranged widely for these same runs, it has been concluded that the bottom strains observed are most likely faulty. It is planned to resolve this issue, if further trials are to be conducted.

CALCULATIONS OF STRESS SENSITIVITIES

1. MAIN DECK VERTICAL BENDING STRESS

SHUNT CALIBRATION = $R_S = 100^K\Omega$

LEAD WIRE RESISTANCE = $R_L = 6.75\,\Omega$

BRIDGE RESISTANCE = $R_A = 240\,\Omega$ /ARM

GAGE FACTOR = $F = 2.0$

NUMBER OF ACTIVES = $n = 2$

POISSON'S RATIO = $\mu = .28$

SIMULATED STRESS FROM SHUNT.

$$\sigma_S = E R_A / n F (1-\mu) R_S$$
$$= (30\times10^6)(240)/(2)(2.0)(.72)(100{,}000)$$
$$= 25{,}000 \text{ psi}$$

STRESS SIMULATED BY SHUNT AT INSTRUMENTATION

$$\sigma_{S\,INSTR} = \sigma_S \left(1 + \frac{4R_L}{R}\right) = 25{,}000\left(1 + \frac{4\times6.75}{240}\right)$$
$$= 27{,}812 \text{ psi}$$

OUTPUT FROM INSTRUMENTATION SHUNT = 6.32 volts

SENSITIVITY = 27812 psi / 6.32 volts = 4400 psi/volt

SHUNT SIMULATES MATERIAL COMPRESSION, THEREFORE PLUS VOLTS CORRESPONDS TO COMPRESSION OR SHIP SAG.

2. MIDSHIP LATERAL BENDING

SIMULATED STRESS FROM SHUNT

$$\sigma_s = E R_A / n F (1-\mu) R_s$$
$$= (30 \times 10^6)(240)/(2)(2.0)(.72)(100,000)$$
$$= 25,000 \text{ psi}$$

STRESS SIMULATED BY SHUNT AT INSTRUMENTATION

$$\sigma_{s_{INSTR}} = \sigma_s \left(1 + {4R_L}/{R_A}\right) \qquad R_L = 8.0$$
$$= 25,000 \left(1 + {4 \cdot 8}/{240}\right)$$
$$= 28,333$$

OUTPUT FROM INSTRUMENTATION SHUNT = + 6.39 volts

SENSITIVITY = 28,333 psi / 6.39 volts = 4434 psi/volt

SHUNT SIMULATES MATERIAL COMPRESSION, THEREFORE PLUS VOLTS CORRESPONDS TO THE PORT SIDE OF THE SHIP BEING IN COMPRESSION DUE TO LATERAL BENDING.

3. MIDSHIP BOTTOM VERTICAL BENDING

SIMULATED STRESS FROM SHUNT

$$\sigma_s = R_A E / n F R_s$$
$$= (240)(30 \times 10^6) / (2)(2.035)(100,000)$$
$$= 17,690 \text{ psi}$$

STRESS SIMULATED BY SHUNT AT INSTRUMENTATION

$$\sigma_{s,INSTR} = \sigma_s \left(1 + {}^{4R_L}/_{R_A}\right) \qquad R_L = 70$$

$$= 17690\left(1 + {}^{4 \times 70}/_{240}\right)$$
$$= 19753 \text{ psi}$$

OUTPUT FROM INSTRUMENTATION SHUNT = 1.93 volts

SENSITIVITY = 19753 psi / 1.93 volts = 10,234 psi/volt

SHUNT SIMULATES MATERIAL COMPRESSION, THEREFORE PLUS VOLTS CORRESPONDS TO COMPRESSION OR SHIP HOG.

4. MIDSHIP TORSIONAL STRESS

SHEAR STRESS SIMULATED BY SHUNT

$$\tau_s = R_A E / n F R_s (1+\mu)$$

$$= (121)(30\times10^6)/(4)(2.04)(250,000)(1.3)$$

$$= 1368 \text{ psi}$$

STRESS SIMULATED BY SHUNT AT INSTRUMENTATION

$$\tau_{s_{INSTR}} = \tau_s \left(1 + \frac{4R_L}{R_A}\right) \qquad R_L = 7$$

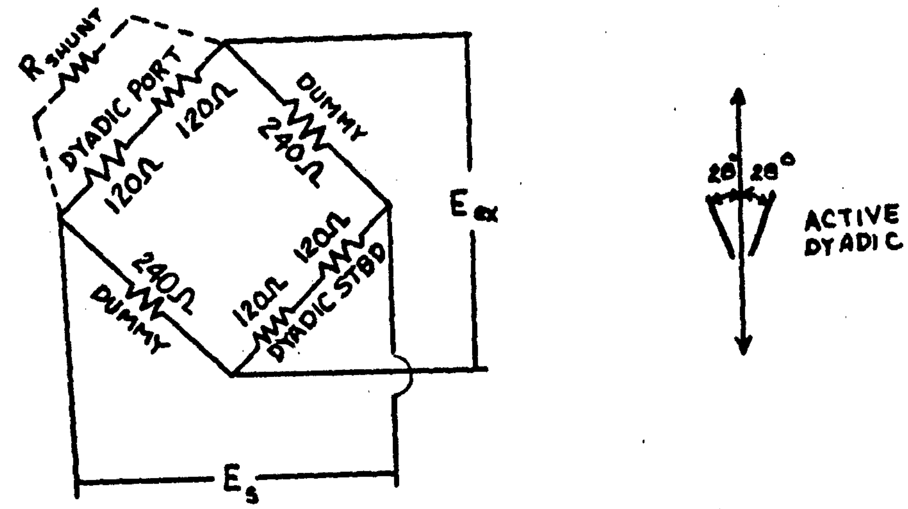
$$= 1368 \left(1 + {}^{4\times7}/_{121}\right) = 1684 \text{ psi}$$

OUTPUT FROM INSTRUMENTATION SHUNT = + 1.38 volts

SENSITIVITY = 1684 psi / 1.38 volts = 1220 psi/volt

SHUNT SIMULATES COMPRESSION IN FORWARD PORT SHEAR GAGE, WHICH WOULD BE CAUSED BY TWISTING SUCH THAT THE PORT BOW WOULD BE DOWN AND THE STARBOARD BOW WOULD BE UP.

BRIDGE CONFIGURATION MAIN DECK BENDING



BRIDGE CONFIGURATION LATERAL BENDING

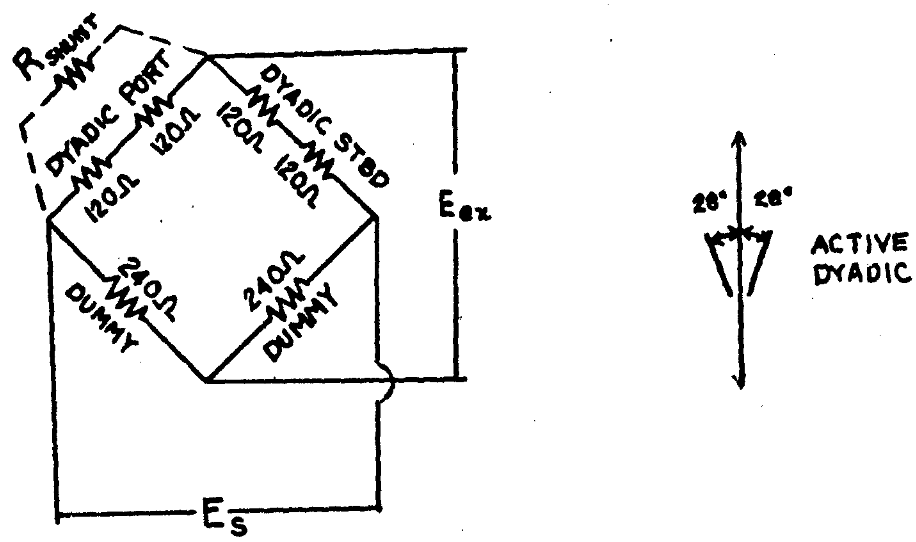
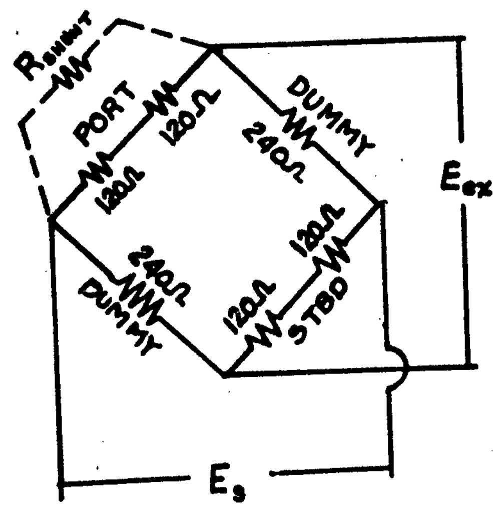


Figure A1 - Lateral and Main Deck Bending Bridge Configurations

BRIDGE CONFIGURATION - MIDSHIP BOTTOM BENDING



BRIDGE CONFIGURATION - MIDSHIP TORSION

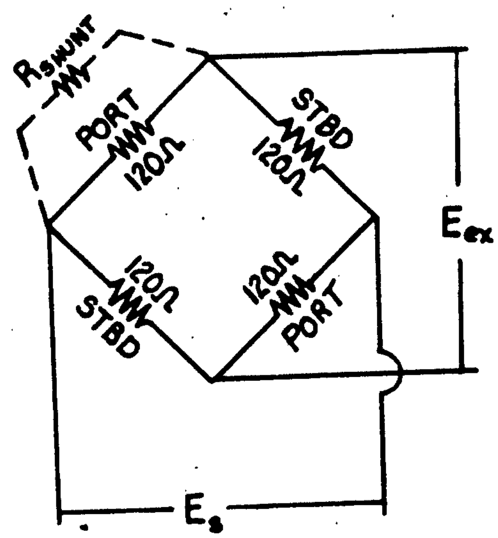


Figure A2 - Torsion and Bottom Bending Bridge Configurations

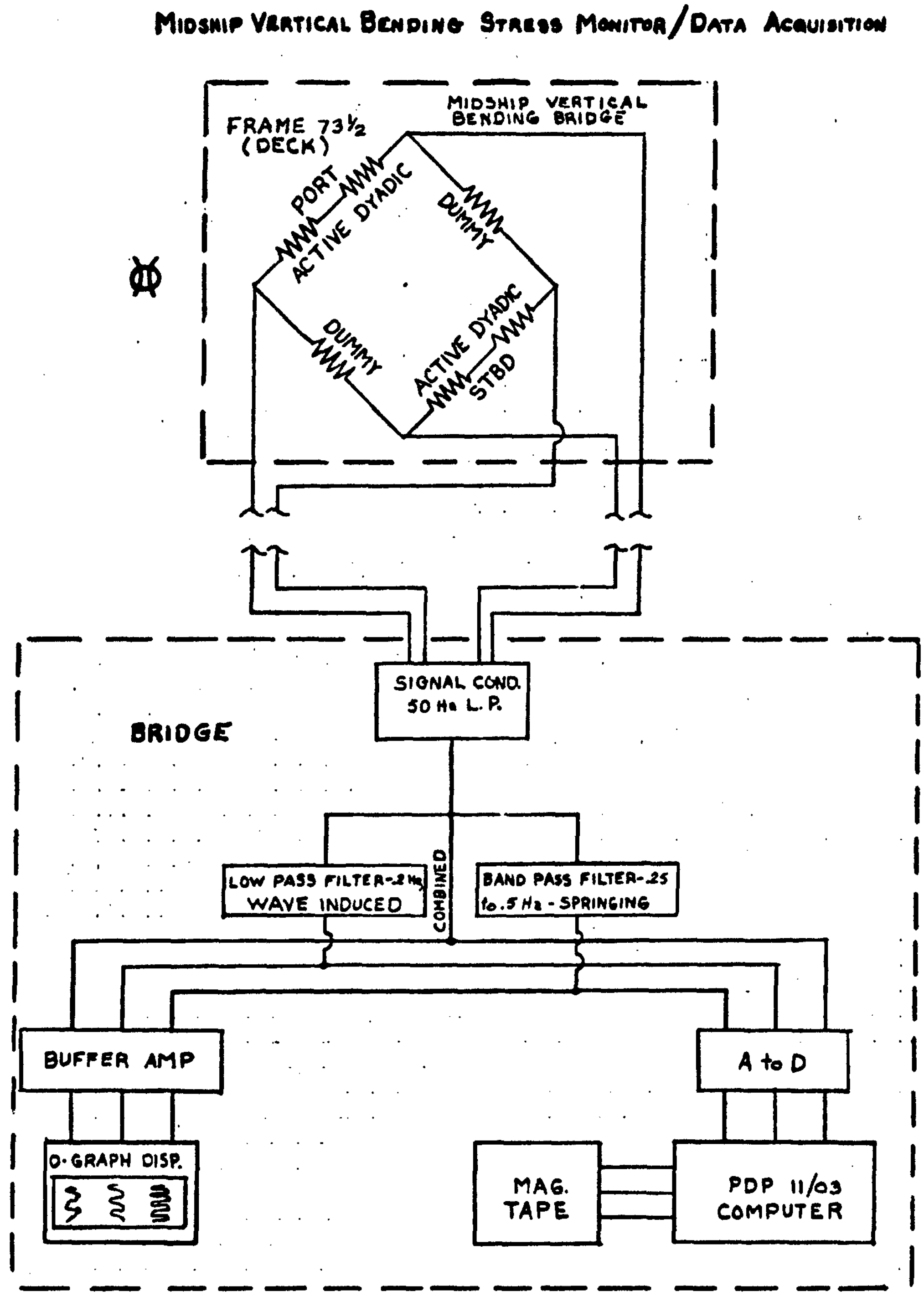


Figure A3 - Midship Vertical Bending Stress Monitor/Data Acquisition Block Diagram

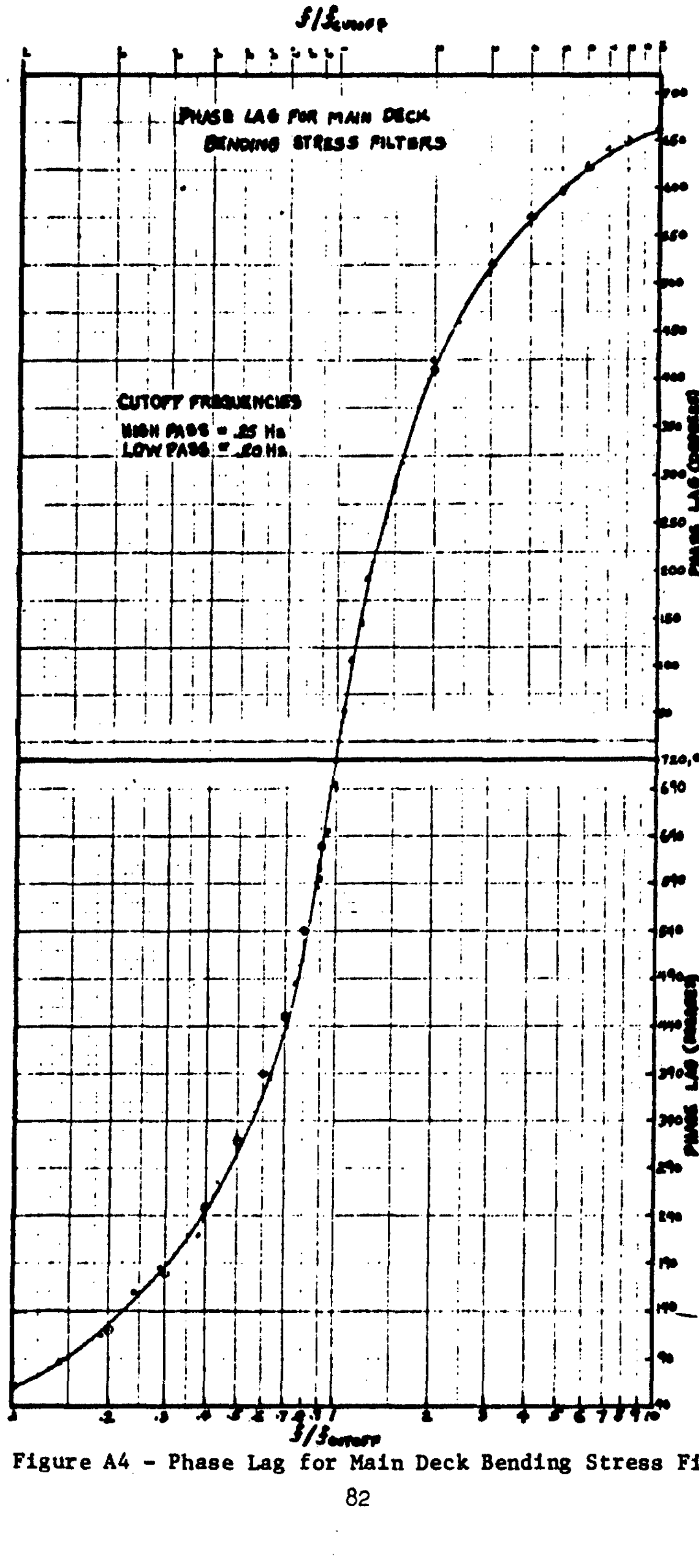


Figure A4 - Phase Lag for Main Deck Bending Stress Filters

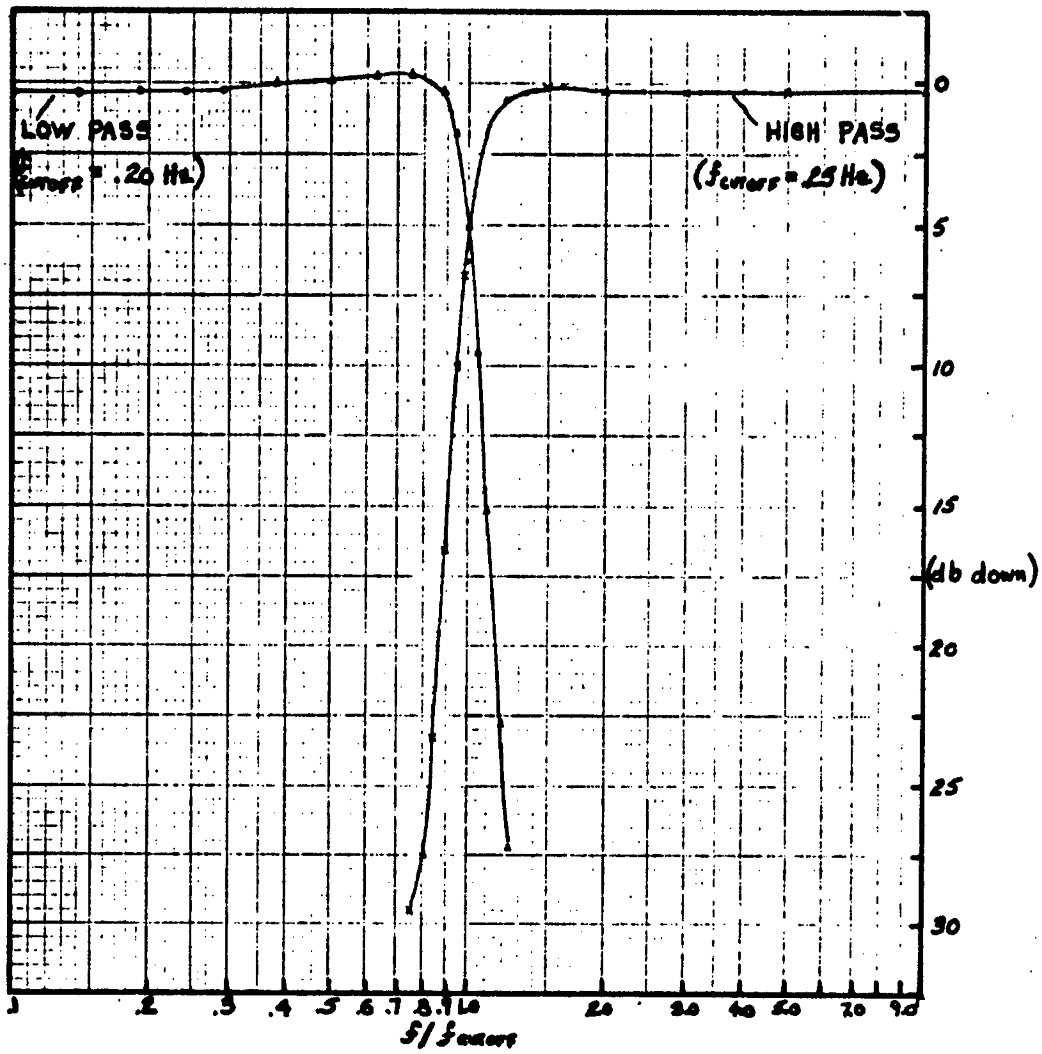
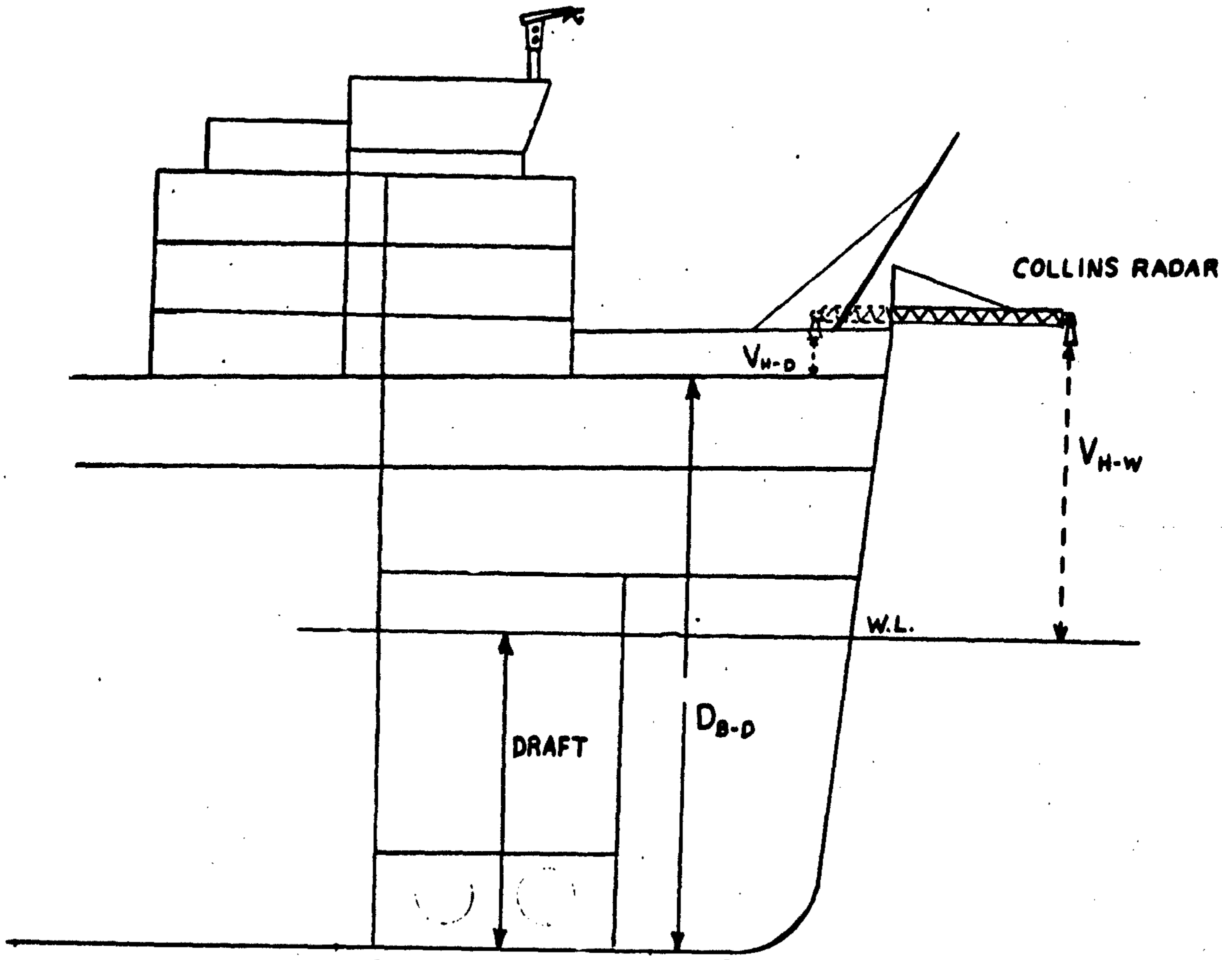


Figure A5 - Rolloff for Main Deck Bending Filters



PROCEDURE FOR COLLINS RADAR RANGE CALIBRATION

1. POSITION RADAR HORNS VERTICALLY OVER WATER, TAKE VOLTAGE READING - V_{H-W}
2. SWING COLLINS HORNS IN OVER DECK AND TAKE SECOND READING - V_{H-D}
3. RECORD SHIP DRAFT

$$\text{RANGE SENSITIVITY} = \frac{D_{B-D} - \text{DRAFT}}{V_{H-W} - V_{H-D}} = \frac{\text{FT}}{\text{VOLT}} \text{ (DECREASING RANGE)}$$

TYPICALLY,

$$\text{SENSITIVITY} = \frac{(57.75 - 19.67)\ \text{FT}}{(.003 - 2.48)\ \text{VOLTS}} = -15.5\ \text{FT/VOLT (DECR. RANGE)}$$

Figure A6 - Collins Radar Calibration Procedure

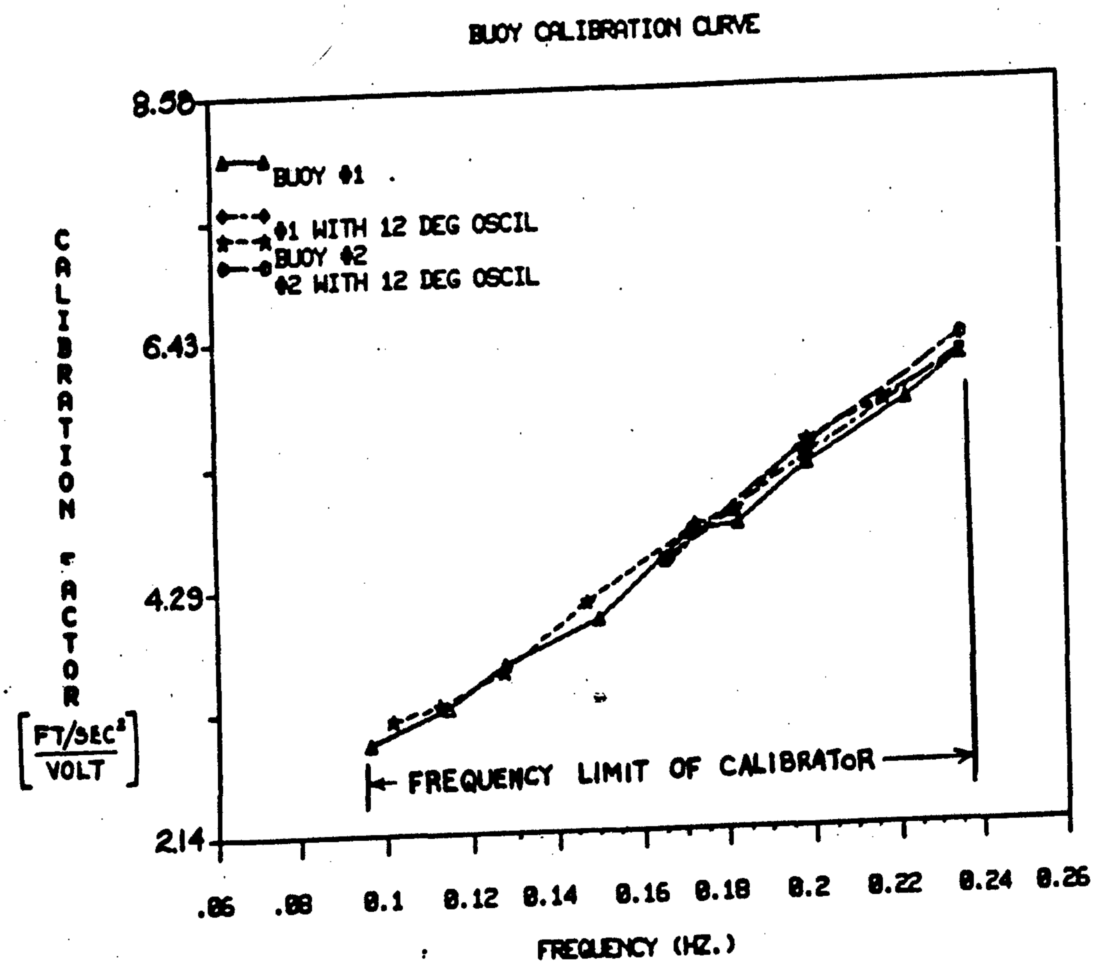


Figure A7 - Wave Rider Buoy Acceleration/Voltage Sensitivity

TABLE A1 - PRESSURE GAGE SENSITIVITIES

Gage Number	Pressure Gage Range (psi)	Lab Sensitivity (psi/volt)	Field* Sensitivity (psi/volt)
1	50	2.495	2.550
2	50	2.515	2.570
3	50	2.545	2.600
4	50	2.485	2.540
5	50	2.520	2.575
6	25	1.225	1.255
7	25	1.250	1.285
8	100	4.980	5.090
9	50	2.480	2.535
10	50	2.505	2.560
11	50	2.520	2.575
12	50	2.520	2.575
13	50	2.530	2.585
14	50	2.530	2.585
15	50	2.520	2.575

* Field sensitivity arrived at by comparing instrument shunt in lab ($R_L = 0$) with instrument shunt in field and calculating R_L; then field sensitivity arrived at by, field sensitivity = lab sensitivity x $(1 + {}^{2R_L}/_R)$ plus volts is positive pressure against the hull.

TABLE A2 - PITCH, ROLL, AND HEAVE ACCELERATION SENSITIVITIES

Measurement	Calibration	Voltage Output	Sensitivity
Pitch	10° Bow Up	+ .135	7.40 °/volt
Roll	10° To Port	+ .146	6.83 °/volt
Heave	2 g's Down	+24.25	2.57 ft/sec^2/volt

TABLE A3 - NRL INSTALLED TRANSDUCER SENSITIVITIES

MEASUREMENT	SENSITIVITY	SENSE
Collins Radar Range	15.50 ft/volt	Increasing Range @ 25° to Vertical
Collins Vertical Acceleration	1.855 ft/sec^2/volt	Acceleration Up
Collins Horizontal Acceleration	3.240 ft/sec^2/volt	Acceleration to STBD
NRL Range	24.61 ft/volt	Increasing Range
NRL Vertical Acceleration	1.408 ft/sec^2/volt	Acceleration Up
NRL Horizontal Acceleration	2.512 ft/sec^2/volt	Acceleration to Port

APPENDIX B

MAGNETIC TAPE FORMAT FOR CORT DATA ACQUISITION

INTRODUCTION

The magnetic tape format description which follows was developed by the DTNSRDC Central Instrumentation Department (CID) to facilitate data transfer between the many minicomputers at the Center and so that data tapes generated could be used for further analysis on the Center's large CDC machines. Some initial investigations showed that the only constraint in the transfer of data was with (surprisingly) the CDC machine. It could only handle record lengths of less than or equal to 512 sixty-bit words on nine track tape (this is not a limitation with their seven track tapes). This limitation was a great disappointment since it was hoped to be able to use long record lengths in order to achieve high data acquisition throughput rates (it is known that there exists a trade-off with regard to the length of tape records and the length of the inter-record gaps). With this in mind it was decided to use fixed length record lengths for the mag tape format of 30720 bits or 1920 sixteen-bit words for minicomputers. This format is currently used on our Hewlett-Packard, Raytheon and Digital Equipment Minicomputers and the data tapes generated by these minicomputers have been used for data analysis on the Center's CDC machines.

In the development of the standard for magnetic tapes, one had to keep in mind that different systems have different capabilities in the number and kinds of channels that can be acquired. The RAYTHEON system had the largest numbers of A/D channels (128 channels) and so it was the de-facto standard. The mag tape formats were, therefore, designed with 128 channel capability even though many data acquisition systems including the one on the CORT have only 32 channels.

MAG TAPE FORMAT OVERVIEW

The tape format is a fixed record length, file oriented tape. That is to say that each record is a fixed length (1920 sixteen-bit words) and that there are file marks between groupings of data for a particular data collection run. The logical end-of-tape is signified by a double end-of-file. Each file on tape also has a fixed format, where the first record in the file contains constant, calibration, and identification (id) information about the data that is to follow. The data records are next (fixed length) and continue until an end-of-File is detected.

THE CONSTANT, CALIBRATION, AND ID (CCI) RECORD

In the following discussion, please note that the word length of the minicomputer that we have is sixteen bits and so it may be assumed that when word is specified, one assumes a sixteen-bit word length. Integer numbers are stored in sixteen bits (using two's complement notation) while floating-point numbers require multiple words. In the case of the PDP-11, the floating-point numbers require two sixteen-bit words. If the mag tape is to be read on a machine other than the machine where the data was recorded, the user will have to write a routine to convert the floating-point numbers into the other machine's internal floating-point format.

The CCI record is again divided into eight fields called 1) CONSTANTS, 2) SYSTEM SENSITIVITIES, 3) GAIN, 4) TRANSDUCER SENSITIVITIES, 5) ZERO, 6) REFERENCE, 7) CHANNEL ID, and 8) TITLE fields. These individual fields will now be described.

CONSTANTS — This field holds integer contant information about the run and is 64 integer words in length.

Word 1 is the RUN number assigned by the engineer to this particular collection of data.

Word 2 is called the POINT number. The POINT number is a unique and sequential number identifier for the file of data, and it is possible to have many data collection "points" within a particular "run".

Word 3 contains the total number of channels that were acquired. The total number of channels is the sum of the total number of analog channels being recorded and the total number of digital channels recorded.

Word 4 is the sample period that was requested by the user and is stored as the number of milliseconds between scans of data. A scan is defined as one sweep of the A/D and all associated digital channels. When data is collected, one scan is acquired as fast as possible to minimize skew between channels. Then, the computer waits the sample period time before acquiring the next scan of data. This is known as "burst" mode data acquisition and is quite different than the constant sample rate acquisition mode that is more common.

Word 5 and word 6 contain the requested time of data collection, with word 5 containing the requested seconds and word 6 containing the requested number of milliseconds.

Word 7 contains the total number of channels used on the first A/D.

Word 8 contains the total number of digital channels recorded.

Word 9 is used to indicate the number of frames stored in each 1920 data record. A frame is defined as the number of data channels in one scan of data (word 3).

Word 10 contains the number of the last channel of interest on the A/D.

Words 11, 13, 14, and 15 are reserved for system use and are currently unused and should contain zeros.

Word 12 contains the total number of channels used on the second A/D.

Word 16 is unused.

Word 17 is a flag to indicate whether or not data was acquired using the internal precision clock or the SL-7 external time base. A "0" indicates that the SL-7 external time base was used while a "1" indicates the use of the computer's interal clock.

Word 18 is used to store the number of averages that are used in the determination of the ZERO or the REFERENCE.

Words 19-29 are unused.

Words 30-33 are ASC II, a string of nine characters that describe the time at which data collection began.

Words 34-39 are unused.

Word 40 contains a pointer update position number. The word 40 will dictate where the title update begins (i.e., what column to begin)—moving it will allow you to only update a portion of the title field to effectively allow you to have a title and a sub-title.

Words 41-51 contain header log information stored as follows:

41 - North Latitude in degrees (XX)

42 - North Latitude in minutes (XX)

43 - West Longitude in degrees (XX)

44 - West Longitude in minutes (XX)

45 - Vessel Speed in mph (XX.X)

46 - Vessel Heading in degrees (XXX)

47 - Vessel Draft in feet (XX)

48 - Wind Direction in degrees (XXX)

49 - Wind Speed in knots (XX)

50 - Wave Direction in degrees (XXX)

51 - Wave Height in feet (XX)

Words 52-64 are unused.

SYSTEM SENSITIVITIES — This buffer (128 floating-point words = 256 sixteen-bit computer words) contains the information that is required to convert A/D counts into Engineering Units (EU). This field is floating-point in type (real—2 words —format is machine dependent floating- point representation) and has units of EU/count. The information is stored sequentially starting with channel 1.

GAIN — The gain buffer stores the gain of the signal conditioning. The buffer is filled by the data collection program just prior to the collection of data if the computer has remote gain read capability, else it must be manually filled by the operator if no remote gain read is available. Normally, its value is "1" to signify that no gain read is available. The units of this buffer are not really GAIN but 1000/GAIN switch reading, or millivolts per full scale deflection (the reason will become clearer later on when terms are combined to calculate Engineering Units). Again 128 channels have been allocated (integer type) starting with channel 1.

TRANSDUCER SENSITIVITIES —This buffer is used by the system to compute the SYSTEM SENSITIVITIES. The number entered here is the value of the shunt for the particular channel (in Engineering Units) divided by either the millivolts per full scale (at the time that the shunt is being performed) or 1000/GAIN switch reading (again at the time of the shunt). The philosophy here is that the shunt gain may be different than the gain used at the time of data collection. In order to compute SYSTEM

SENSITIVITY, the computer takes a base-line reading and then a shunt reading. This delta A/D count reading represents the number of counts that corresponds to the value stored in the TRANSDUCER SENSITIVITIES buffer. In order to get EU count take the TRANSDUCER SENSITIVITIES value and divide it by the delta count reading. This is then SYSTEM SENSITIVITY. Again note that 128 channels of information have been alloted for this buffer and that the representation is machine dependent floating-point that occupies two sixteen-bit words per value. Zero — The ZERO buffer (128 channels of floating-point values) has the value of the instrumentation zero. This is normally filled prior to data collection and is subtracted out of the calculation for Engineering Unit conversion in order to get rid of amplifier drift or offsets. The value stored in the buffer is A/D counts multiplied by the GAIN (1000/GAIN switch reading or millivolt per full scale) of the instrumentation when the ZERO was taken.

REFERENCE — In some tests, such as air cushion or wind tunnel tests, it is desirable to also include a reference level that will be used (somehow) in the calculations to compute Engineering Units. 128 channels of floating-point values have been reserved for this usage. Again, this buffer is stored as A/D ccounts times GAIN at the time the reference was taken. Channel 1 is first as in all the other fields.

CHANNEL ID — This field contains ASCII data that is channel identifier information. Ten characters have been allocated for up to 128 channels where two ASCII characters may be stored in a sixteen-bit word. The total length of this field is therefore 1280 words.

TITLE — This last buffer contains the title of the trial and may be used to store information about the test, such as model name, ship name or other administrative

information. 128 characters are available to store this information (again 2 ASCII character per word) so that 64 words are required for this field.

ENGINEERING UNIT CONVERSION CALCULATIONS

If we can assume that the data collection program has filled all the above buffers correctly, the calculation of the actual Engineering Units is straightforward.

EU = (((A/D counts * GAIN) - ZERO) * SYSTEM SENSITIVITY)

The units above work out to be Engineering Units. Note that in this case the GAIN is 1 due to the fact that the computer has no remote gain read capability.

DATA RECORDS

As noted above, the CCI record is written to tape at the start of data collection, and is then followed by the data records. The data records appear sequentially until an end-of-file mark. The data contain Word 9 frames of data except the last record, which may not be completely filled. For this record, any unused portions of the record are filled with a "fill" character which is a 27703 (decimal) or 111711 (octal).

The frames are stored as follows: one scan of the A/D channels appear first (starting with channel 1), followed by the digital channel.

The one last detail of the data record is the fact that different A/D converters present the data to the computer in different forms. The DEC A/D converter present the data as right justified (12 bits) counts in the range of 0-4095. In order to get a +/- range of counts, the user has to subtract 2048 when the data is read back from tape. In many cases the data acquisition routine does not have enough time to process this data in order to format it for the user before the data is written to tape due to the high data throughput rates requested by the user. It is for that reason that the data has to be reformatted by the applications program.

DATA REDUCTION OF TAPES WRITTEN IN CID FORMAT

The data reduction process is not too involved when the data is written using this format for magnetic tapes. First, the tape has to be positioned to the proper file. Tape positioning may be done in any convienent way as each file has a unique POINT number. So, determine the point number of interest from the data acquisition log, and skip files until you find a file where the ID record (it is the first record in the file) has the desired POINT and RUN number. Read in the entire ID record as it will be required later for EU conversion and titling of output. Use routine DREAD to read data records off the tape, and with the para the parameters passed back to the main routine, it is very easy to construct a double DO LOOP in FORTRAN to sequentially process all the frames of data in the file. The subroutines are included in this appendix that show a set of routines to compute the MEAN, MIN, MAX, and RMS of all channels on a CID standard data tape.

It is recognized that certain applications don't require that all the channels on a data tape be processed. In that case, the user will have to consult the run log to determine the position of the desired channels on the A/D patch list. Their position on the A/D corresponds to its position in the data frame. For example, we acquired 32 channels of analog information and had one digital channel. We are only interested in processing the last 16 channels on the A/D. So, we read in one data record and instead of starting the data reduction with the first channel in the frame, we add a bias of 16 to our buffer pointer. Therefore, the first channel we will look at is the seventeenth channel and we can proceed sequentially for the 16 channels of interest. Then, before we proceed to the next frame, we again add 16 to our buffer pointer in order to skip over the first 16 channels of the next frame that we want to ignore.

Subroutine MMMRMS

```
      SUBROUTINE MMMRMS
C-----------------------------------------------------------------------
C
C
C     THIS SUROUTINE READS A CID PDP DATA TAPE.
C     IT CALCULATES MEAN MAX MIN & RMS FOR EACH CHANNEL.
C     IT EU'S THE RESULTS AND WRITES THEM TO THE LINE PRINTER.
C     IT ALSO PUTS THE RESULTS IN A DISK FILE
C
C     WRITTEN BY JCD3     NOVEMBER 1978
C
C
C-----------------------------------------------------------------------
C
      INTEGER IPH(2),ITIME(4),IDATE(5),ITIME2(4),IGAGE(40)
      INTEGER DBUFF(1920)
      INTEGER RUN,POINT,YES
      INTEGER MAX(40),MIN(40)
      REAL XBAR(40),AMAX(40),AMIN(40)
      REAL MEAN,RMS
      REAL COUNT(40)
C
C
C     The following COMMON block is the CID ID record
C
C
      COMMON KONS(64),SSENS(128),IGAIN(128),TSENS(128),ZERO(128)
      COMMON REF(128),ICHID(5,128),ITITL(64)
C
C
C     THESE ARE ADDITIONS
C
C
      COMMON MEAN(40),RMS(40),ICHAN
      COMMON COUNT
C
      EQUIVALENCE(ITIME2(1),KONS(30)),(IGAGE(1),REF(80))
      EQUIVALENCE(ITIME,KONS(22))
      EQUIVALENCE (RUN,KONS(1)),(POINT,KONS(2))
      EQUIVALENCE (NCOMM,KONS(3)),(NADC,KONS(10))
      EQUIVALENCE(MAX(1),AMAX(21)),(MIN(1),AMIN(21))
      DATA IPH/' A',' B'/
C
C
C_______________________________________
C
C
C OUTPUT CONSTANTS TO LINE PRINTER
C
      CALL KONOUT(IDATE,ITIME)
C
```

```
C
C READ DATA TAPE AND CALCULATE MEAN, MAX, MIN, & RMS IN COUNTS
C
      CALL AVGRMS(DBUFF,NCOMM,NADC,MEAN,RMS,MAX,MIN,COUNT)
C
C
C SUBTRACT THE ZERO AND CONVERT TO ENGINEERING UNITS
C
C
      DO 569 I=1,NCOMM
      RGAIN=IGAIN(I)
      RZERO = ZERO(I)
      RSENS = SSENS(I)
      XBAR(I)=(MEAN(I)*RGAIN-RZERO)*RSENS
      AMAX(I)=(FLOAT(MAX(I))*RGAIN-RZERO)*RSENS
      AMIN(I)=(FLOAT(MIN(I))*RGAIN-RZERO)*RSENS
      RMS(I)=RMS(I)*RGAIN*RSENS
569   CONTINUE
C
C
C CALCULATE TIME OF POINT
C
C     USE CHANNEL 1 COUNT CAUSE THAT SHOULD NEVER BE
C     ONE OF THE CHANNELS THAT IS SPECIAL AND HAS
C     ERROR INDICATORS.
C
C
      TTIME=FLOAT(KONS(4))*0.001*COUNT(1)
C
C
C WRITE HEADER TO LINE PRINTER
C
      WRITE(6,9110) (ITITL(I),I=1,64)
9110  FORMAT(/////,1X,64A2)
C
      WRITE(6,9100) KONS(2),KONS(1),
     1        ITIME2,IDATE,ITIME,KONS(4),TTIME
9100  FORMAT(//' P O I N T ',I8,5X,'R U N',I8,
     1        ' TIME OF RUN',5X,4A2,//,
     2        ' TIME AND DATE OF ANALYSIS',5X,4A2,A1,3X,4A2,//,
     3                ' S C A N   P E R I O D =  ',I5,'  M S ',10X,
     4                'DURATION OF POINT = ',F15.3,'  S E C'//)
C
C
      WRITE(6,90000)
90000 FORMAT(1X,'C H     ',10X,'C H   I D',
     1        13X,'M E A N',10X,'M A X',10X,
     2                'M I N',10X,'R M S',10X,'COUNT')
C
C
C WRITE PARAMETERS TO LINE PRINTER
C
      DO 1100 I=1,NCOMM
      WRITE(6,9010) I,(ICHID(I2,I),I2=1,5),
     1        XBAR(I),AMAX(I),AMIN(I),RMS(I),COUNT(I)
```

```
9010  FORMAT(I5,13X,5A2,10X,1PE11.4,
     1        5X,1PE11.4,4X,1PE11.4,4X,1PE11.4,4X,1PE11.4)
1100  CONTINUE
      WRITE(6,9999)
9999  FORMAT(1H1)
C
      RETURN
C
C
      END
```

Subroutine AVGRMS

```
      SUBROUTINE AVGRMS(DBUFF,NCOMM,NADC,AVG,RMS,MAX,MIN,COUNT)
C
C
C______________________________________________
C
C
C
C     WRITTEN BY  JOHN DAVIES          15-MARCH-1976
C
C     MOD 2 BY NED W.  RHODES          11-MAY-76
C     MOD 3 BY NED W.  RHODES          15-MAY-76
C     MOD 4 BY JOHN DAVIES              7-NOV-78
C     MOD 5 BY NED   FOR THE CORT      23-JUL-79
C
C     THIS SUBROUTINE READS ONE FILE FROM A CID STANDARD DATA TAPE.
C     IT COMPUTES THE AVERAGE, RMS, MAX & MIN FOR EACH DATA CHANNEL.
C     THE PROGRAM COMPUTES AND RETURNS EVERYTHING IN COMPUTER COUNTS!
C
C
C     CALLING SEQUENCE:
C
C         CALL AVGRMS(DBUFF,NCOMM,NADC,AVG,RMS,MAX,MIN,COUNT)
C
C       WHERE:
C
C             DBUFF    A 1920 WORD INTEGER ARRAY IN THE CALLING
C                      PROGRAM THAT WILL BE USED TO BUFFER THE DATA
C                      INTO THE COMPUTER.
C
C             NCOMM    TOTAL NUMBER OF CHANNELS MULTIPLEXED IN DBUFF
C
C             NADC     NUMBER OF CHANNELS FROM THE ADC MUX
C
C             AVG      A REAL VECTOR WHERE THE AVERAGE WILL BE STORED
C
C             RMS      A REAL VECTOR WHERE THE RMS WILL BE STORED
```

```
C
C            MAX      AN INTEGER VECTOR WHERE THE MAX WILL BE STORED
C
C            MIN      AN INTEGER VECTOR WHERE THE MIN WILL BE STORED
C
C            COUNT    A REAL VALUE CONTAINING THE NUMBER OF AVERAGES
C                     PERFORMED IN AVGRMS
C
C
C
C
C
C
C     NOTE:
C              1.     THE CONSTANT RECORD MUST BE READ BEFORE
C                     CALLING THIS SUBROUTINE
C
C
C______________________________________
C
C
      INTEGER         DBUFF(1)
      DIMENSION AVG(1),RMS(1),MAX(1),MIN(1)
      REAL COUNT(32)
C
C
C. INITIALIZE!
C
C
      DO 1 I=1,NCOMM
      COUNT(I) = 0.0
      AVG(I)=0.0
      RMS(I)=0.0
      MAX(I)=-32767
      MIN(I)=32767
    1 CONTINUE
C
C
C. READ THE NEXT DATA RECORD
C
C
    5 CALL DREED(DBUFF,NCOMM,NADC,ISTAT)
C
C
C. CHECK FOR END OF FILE
C
      IF(ISTAT.EQ.-1)GO TO 30
C
C
C. SET POINTER WITHIN DATA BUFFER TO ZERO
C
      IPT=0
C
```

```
C
C COMPUTE THE SUM, SUM OF THE SQUARES, MAX, MIN, & TOTAL   OF SCANS
C  OF EACH CHANNEL RECORD BY RECORD
C
C
      DO 10 J=1,ISTAT
      DO 10 I=1,NCOMM
      IPT=IPT+1
12    IVALUE=DBUFF(IPT)
      VALUE = IVALUE
      AVG(I)=AVG(I)+VALUE
      RMS(I)=RMS(I)+VALUE*VALUE
      IF(IVALUE.GT.MAX(I))  MAX(I) = IVALUE
      IF(IVALUE.LT.MIN(I))  MIN(I) = IVALUE
      COUNT(I) = COUNT(I) + 1.0
10    CONTINUE
C
C
C GO READ ANOTHER DATA RECORD
C
      GO TO 5
C
C
C
C WHEN AN EOF OCCURS WE GET HERE
C
C CALCULATE THE AVERAGE AND RMS
C
C
   30 DO 40 I=1,NCOMM
      IF(COUNT(I).EQ.0.0) GOTO 41
      AVG(I)=AVG(I)/COUNT(I)
      RMS(I)=SQRT(ABS(RMS(I)/COUNT(I)-AVG(I)*AVG(I)))
      GOTO 40
41    AVG(I) = 0.0
      RMS(I) = 0.0
   40         CONTINUE
C
C
      RETURN
      END
```

Subroutine DREED

```
      SUBROUTINE DREED(IBUFF,NCOMM,NADC,ISTAT)
C
C     ROUTINE TO READ A CID/PDP DATA TAPE.  THIS
C     ROUTINE WILL READ A DATA RECORD, SHIFT DATA
C     AND LET CALLER KNOW HOW MANY SCANS IN THE RECORD.
C
```

```
C
C
C       CALL DREAD(IBUFF,NCOMM,NADC,ISTAT)
C
C       IBUFF - 1920 WORD BUFFER IN CALLING PROGRAM TO HOLD DATA
C       NCOMM - NUMBER OF CHANNELS COMMUTATED
C       NADC - NOT USED IN THIS VERSION
C       ISTAT -         RETURNED VALUE. +  NUMBER OF SCAN/RECORD
C                                       -  END OF FILE ENCOUNTERED
C
        DIMENSION IBUFF(1)
        DATA IFILL/-27703/
        DATA IMT2/0/
C
C
C       FILL CHARACTER
C
        ISTAT=1920/NCOMM
        LPOS=ISTAT*NCOMM
C
C
C       READ DATA RECORD
C
        CALL BFINP(IMT2,IBUFF,1920)
        IF(IEOF(IMT2).GE.0) GO TO 10
        ISTAT=-1
        RETURN
C
C
C       CHECK FOR FILL CHAR IN LAST POSITION
C
  10    IF(IBUFF(LPOS)-IFILL) 3,4,3
C
C
C       FIND LAST SCAN OF GOOD DATA IN RECORD
C
  4     J=LPOS-NCOMM+1
        DO 5 I=1,J,NCOMM
        IF(IBUFF(I)-IFILL) 5,6,5
  5     CONTINUE
  6     ISTAT=(I-1)/NCOMM
C
C
C       FIX DATA BUFFER
C
  3     IPT = 1
        IDIF = NCOMM - NADC
        DO 20 J = 1,ISTAT
        DO 21 I = 1,NADC
        IBUFF(IPT) = IBUFF(IPT) - 2048 !CONVERT TO +/- COUNTS
        IPT = IPT + 1
21      CONTINUE
        IPT = IPT + IDIF                  !SKIP OVER DIGITAL CHANNELS
20      CONTINUE
        RETURN
        END
```

APPENDIX C

HEADER LOGS FOR M/V S.J. CORT DATA RUNS

A listing of the header logs for all data runs taken during the course of the Fall wave/stress/pressure measurements on the CORT follows the text of this appendix. These logs contain information as to the ship's speed, heading, location and draft in addition to the observed wind and wave conditions existing at the time of the data run. Also included in the logs is information pertaining to the date of the run, time of day and remarks before and after the run which might provide additional information about the run.

The location reported in terms of North latitude and West longitude is the best estimate by the mate on watch as to the actual location of the ship at the start of the data run. Vessel speed was determined by the mates on watch by logging distance covered over a period of time. No direct reading of ship speed is available. Vessel heading is that read directly from the ship gyrocompass. The wind speed and direction are the true wind speed and direction existing at the start of the data run as computed at that time. Wave height and direction are based upon visual estimates of the sea running at the start of the data run. The wave height indicated is a visual estimate of the significant wave height (one third highest) observed before the data run was begun. The wave direction indicated as a visual estimate of the direction of the predominant sea running at the time of the run and is given in terms of where the waves are coming from. As an example of how to determine the wave to ship heading angle we will look at RUN 77. The vessel heading is given as 256 degrees and the wave direction is given as 250 degrees. Then with the ship heading on a course of 256 and the waves coming from 250 degrees, the ship would be encountering the waves from 6^{o} to PORT of the ships bow.

This would be classed as a head sea case in the groupings used in the text.

The vessel draft indicated is the draft at the ships' bow. To establish the trim of the ship for a particular run, Table C1 should be employed to determine the ships draft amidship and aft. For example, if the vessel draft indicated in the log is 15 feet, the corresponding drafts for forward, amidship and aft would be 15'4" forward, 16'11" amidship, and 19'8" aft respectively. These drafts are based upon the different ballast conditions that the ship operates at during the upbound trip. During the downbound or loaded part of the trip the ship draws 27 feet with no trim.

TABLE C1 - CORT DRAFTS FOR LOAD/BALLAST CONDITIONS

CONDITION	LOG ENTRY	DRAFT FWD	DRAFT AMID	DRAFT AFT
Ballast Code 1	12'-12'	12' -5"	15' -8"	19'-6"
Ballast Code 2	15'-16'	15'-4"	16'-11"	19'-8"
Ballast Code 3	17'-18'	17'-0"	18'-11"	21'-3"
Ballast Code 4	19'-20'	20'-7"	20'-7"	22'-0"
Ship Loaded	27'	27'-0"	27'-0"	27'-0"

```
M/V S J CORT FALL TRIALS
          RUN          22          POINT          1
          DATE   27-OCT-79         TIME    18:09:10
          DURATION OF RUN IN MINUTES IS          41.667
          NORTH LATITUDE (DD MM)          45 49
          WEST LONGITUDE (DD MM)          85  0
          VESSEL'S SPEED (MPH - XX.X)    16.3
          VESSEL'S HEADING (DEGREES)       94
          VESSEL'S DRAFT (FEET)            12
          WIND DIRECTION (DEGREES)        155
          WIND SPEED (KNOTS)                9
          WAVE DIRECTION.(DEGREES)        170
          WAVE HEIGHT (FEET)                2
REMARKS
WEST OF MACKINAC BR

End-of-run message
BOW QUARTER SEAS

M/V S J CORT FALL TRIALS
          RUN          24          POINT          2
          DATE   27-OCT-79         TIME    19:47:17
          DURATION OF RUN IN MINUTES IS          20.000
          NORTH LATITUDE (DD MM)          45 51
          WEST LONGITUDE (DD MM)          84 30
          VESSEL'S SPEED (MPH - XX.X)    16.0
          VESSEL'S HEADING (DEGREES)       90
          VESSEL'S DRAFT (FEET)            15
          WIND DIRECTION (DEGREES)        170
          WIND SPEED (KNOTS)               15
          WAVE DIRECTION (DEGREES)        170
          WAVE HEIGHT (FEET)                6
REMARKS
LAKE HURON , UPBOUND.NO VISIBILITY

End-of-run message
BEAM STBD SEA<ON O-GRAPH PAPER

M/V S J CORT FALL TRIALS
          RUN          25          POINT          4
          DATE   28-OCT-79         TIME    08:28:13
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)          46 47
          WEST LONGITUDE (DD MM)          85  0
          VESSEL'S SPEED (MPH - XX.X)    15.0
          VESSEL'S HEADING (DEGREES)      280
          VESSEL'S DRAFT (FEET)            15
          WIND DIRECTION (DEGREES)        330
          WIND SPEED (KNOTS)               18
          WAVE DIRECTION (DEGREES)        330
          WAVE HEIGHT (FEET)                3
REMARKS
WAVE BOUY HELORUNS, WEST OF WHITEFISH BAY UPBOUND

End-of-run message
BOUY SIGNALBAD, RUN ABORTED

M/V S J CORT FALL TRIALS
          RUN          26          POINT          6
          DATE   28-OCT-79         TIME    08:49:21
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)          46 47
          WEST LONGITUDE (DD MM)          85  0
          VESSEL'S SPEED (MPH - XX.X)    15.0
          VESSEL'S HEADING (DEGREES)      280
          VESSEL'S DRAFT (FEET)            15
          WIND DIRECTION (DEGREES)        330
          WIND SPEED (KNOTS)               18
          WAVE DIRECTION (DEGREES)        330
          WAVE HEIGHT (FEET)                3
REMARKS
WAVE BOUY RUN 2

End-of-run message
BOUY SIGNALBAD, RUN ABORTED

M/V S J CORT FALL TRIALS
          RUN          27          POINT          8
          DATE   28-OCT-79         TIME    09:22:07
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)          46 50
          WEST LONGITUDE (DD MM)          85 15
          VESSEL'S SPEED (MPH - XX.X)    15.0
          VESSEL'S HEADING (DEGREES)      280
          VESSEL'S DRAFT (FEET)            15
          WIND DIRECTION (DEGREES)        330
          WIND SPEED (KNOTS)               18
          WAVE DIRECTION (DEGREES)        330
          WAVE HEIGHT (FEET)                6
REMARKS

End-of-run message

M/V S J CORT FALL TRIALS
          RUN          28          POINT          10
          DATE   28-OCT-79         TIME    10:45:21
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)          46 47
          WEST LONGITUDE (DD MM)          85 15
          VESSEL'S SPEED (MPH - XX.X)    15.8
          VESSEL'S HEADING (DEGREES)      292
          VESSEL'S DRAFT (FEET)            15
          WIND DIRECTION (DEGREES)        305
          WIND SPEED (KNOTS)               14
          WAVE DIRECTION (DEGREES)        305
          WAVE HEIGHT (FEET)                4
REMARKS
COFUSE D WAVES

End-of-run message
BOW STBD. SEA
```

```
M/V S J CORT FALL TRIALS
        RUN              29          POINT          12
        DATE   28-OCT-79             TIME     13:04:35
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)            47  0
        WEST LONGITUDE (DD MM)            85 45
        VESSEL'S SPEED (MPH - XX.X)     15.8
        VESSEL'S HEADING (DEGREES)       292
        VESSEL'S DRAFT (FEET)              15
        WIND DIRECTION (DEGREES)         317
        WIND SPEED (KNOTS)                 13
        WAVE DIRECTION (DEGREES)         317
        WAVE HEIGHT (FEET)                  4
REMARKS
STBD. BOW SEA RUN

End-of-run message
D ATA ALSO ON O'GRAPH
```

```
M/V S J CORT FALL TRIALS
        RUN              30          POINT          14
        DATE   29-OCT-79             TIME     21:05:35
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)            47  0
        WEST LONGITUDE (DD MM)            91 30
        VESSEL'S SPEED (MPH - XX.X)     16.3
        VESSEL'S HEADING (DEGREES)        63
        VESSEL'S DRAFT (FEET)              27
        WIND DIRECTION (DEGREES)         243
        WIND SPEED (KNOTS)                 15
        WAVE DIRECTION (DEGREES)          90
        WAVE HEIGHT (FEET)                  2
REMARKS
SUPERIOR, UPBOUND -  CALM SEA

End-of-run message
NONE
```

```
M/V S J CORT FALL TRIALS
        RUN              31          POINT          16
        DATE   30-OCT-79             TIME     14:09:55
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)            47 15
        WEST LONGITUDE (DD MM)            86 40
        VESSEL'S SPEED (MPH - XX.X)     13.8
        VESSEL'S HEADING (DEGREES)       113
        VESSEL'S DRAFT (FEET)              27
        WIND DIRECTION (DEGREES)         143
        WIND SPEED (KNOTS)                  8
        WAVE DIRECTION (DEGREES)         143
        WAVE HEIGHT (FEET)                  3
REMARKS
SUPERIOR, DWNBND. STBD. BOW SEA

End-of-run message
NONE
```

```
M/V S J CORT FALL TRIALS
        RUN              32          POINT          18
        DATE   30-OCT-79             TIME     16:28:08
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)            47 10
        WEST LONGITUDE (DD MM)            86  0
        VESSEL'S SPEED (MPH - XX.X)     14.7
        VESSEL'S HEADING (DEGREES)       113
        VESSEL'S DRAFT (FEET)              27
        WIND DIRECTION (DEGREES)         121
        WIND SPEED (KNOTS)                 14
        WAVE DIRECTION (DEGREES)         121
        WAVE HEIGHT (FEET)                  3
REMARKS
SUPERIOR, DWNBND., HEAD SEA

End-of-run message
SPRINGING EVIDENT.
```

```
M/V S J CORT FALL TRIALS
        RUN              33          POINT          20
        DATE   30-OCT-79             TIME     18:59:26
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)            47  0
        WEST LONGITUDE (DD MM)            85 55
        VESSEL'S SPEED (MPH - XX.X)     14.1
        VESSEL'S HEADING (DEGREES)       113
        VESSEL'S DRAFT (FEET)              27
        WIND DIRECTION (DEGREES)         135
        WIND SPEED (KNOTS)                 25
        WAVE DIRECTION (DEGREES)         135
        WAVE HEIGHT (FEET)                  4
REMARKS
SUPERIOR DWNBND., NEAR WHITEFISH BAY, HEAD SEA

End-of-run message
SOUNDING DEPTH 100 FT
```

END TAPE 1

```
M/V S J CORT FALL TRIALS
        RUN          35            POINT           4
        DATE    31-OCT-79          TIME     15:12:21
        DURATION OF RUN IN MINUTES IS         25.000
        NORTH LATITUDE (DD MM)          45 37
        WEST LONGITUDE (DD MM)          86  5
        VESSEL'S SPEED (MPH - XX.X)    14.8
        VESSEL'S HEADING (DEGREES)     205
        VESSEL'S DRAFT (FEET)           27
        WIND DIRECTION (DEGREES)       101
        WIND SPEED (KNOTS)              17
        WAVE DIRECTION (DEGREES)       101
        WAVE HEIGHT (FEET)               3
REMARKS
MICHIGAN, DWNBND., OFF SO. FOX ISLE, PORT BOW SEA
FIRST RUN, TAPE 2

End-of-run message
FEW SCATTERED WHITECAPS
```

```
M/V S J CORT FALL TRIALS
        RUN          36            POINT           6
        DATE    31-OCT-79          TIME     17:29:33
        DURATION OF RUN IN MINUTES IS         25.000
        NORTH LATITUDE (DD MM)          45  9
        WEST LONGITUDE (DD MM)          86 28
        VESSEL'S SPEED (MPH - XX.X)    14.1
        VESSEL'S HEADING (DEGREES)     203
        VESSEL'S DRAFT (FEET)           27
        WIND DIRECTION (DEGREES)       132
        WIND SPEED (KNOTS)              16
        WAVE DIRECTION (DEGREES)       132
        WAVE HEIGHT (FEET)               3
REMARKS
MICHIGAN, DWNBND., PORT BOW SEA

End-of-run message
CHECKING LSI CLOCK
```

```
M/V S J CORT FALL TRIALS
        RUN          37            POINT           8
        DATE    31-OCT-79          TIME     17:40:02
        DURATION OF RUN IN MINUTES IS         25.000
        NORTH LATITUDE (DD MM)          45  9
        WEST LONGITUDE (DD MM)          86 28
        VESSEL'S SPEED (MPH - XX.X)    14.1
        VESSEL'S HEADING (DEGREES)     203
        VESSEL'S DRAFT (FEET)           27
        WIND DIRECTION (DEGREES)       132
        WIND SPEED (KNOTS)              16
        WAVE DIRECTION (DEGREES)       132
        WAVE HEIGHT (FEET)               3
REMARKS
MICHIGAN, DWNBND., PORT BOW SEA

End-of-run message
LSI CLOCK OFF 10 MINUTES PER HOUR
```

```
M/V S J CORT FALL TRIALS
        RUN          38            POINT          10
        DATE    31-OCT-79          TIME     19:07:30
        DURATION OF RUN IN MINUTES IS         25.000
        NORTH LATITUDE (DD MM)          44 40
        WEST LONGITUDE (DD MM)          86 40
        VESSEL'S SPEED (MPH - XX.X)    14.4
        VESSEL'S HEADING (DEGREES)     184
        VESSEL'S DRAFT (FEET)           27
        WIND DIRECTION (DEGREES)       146
        WIND SPEED (KNOTS)              20
        WAVE DIRECTION (DEGREES)       146
        WAVE HEIGHT (FEET)               3
REMARKS
MICHIGAN, DWNBND., PORT BOW SEA
TIME IS 1955

End-of-run message
SOME PORT SIDE BOW SLAPS
```

```
M/V S J CORT FALL TRIALS
        RUN          39            POINT          12
        DATE    31-OCT-79          TIME     21:04:42
        DURATION OF RUN IN MINUTES IS         25.000
        NORTH LATITUDE (DD MM)          44 12
        WEST LONGITUDE (DD MM)          86 45
        VESSEL'S SPEED (MPH - XX.X)    14.4
        VESSEL'S HEADING (DEGREES)     184
        VESSEL'S DRAFT (FEET)           27
        WIND DIRECTION (DEGREES)       160
        WIND SPEED (KNOTS)              24
        WAVE DIRECTION (DEGREES)       160
        WAVE HEIGHT (FEET)               5
REMARKS
MICHIGAN, DWNBND., PORT BOW SEA
TIME IS 2220

End-of-run message
ERRATIC BEHAVIOR OF SL-7 MAY BE DUE TO SPRAY FROM WAVES
```

```
M/V S J CORT FALL TRIALS
        RUN          40            POINT          14
        DATE    31-OCT-79          TIME     21:54:05
        DURATION OF RUN IN MINUTES IS         25.000
        NORTH LATITUDE (DD MM)          44  5
        WEST LONGITUDE (DD MM)          86 45
        VESSEL'S SPEED (MPH - XX.X)    13.5
        VESSEL'S HEADING (DEGREES)     184
        VESSEL'S DRAFT (FEET)           27
        WIND DIRECTION (DEGREES)       189
        WIND SPEED (KNOTS)              22
        WAVE DIRECTION (DEGREES)       189
        WAVE HEIGHT (FEET)               8
REMARKS
MICHIGAN, DWNBND., HEAD SEA
TIME IS 2330

End-of-run message
BOW SPRAY MAY EFFECT COLLINS SIGNAL
```

```
M/V S J CORT FALL TRIALS
          RUN              41           POINT            16
          DATE    01-NOV-79             TIME       00:25:19
          DURATION OF RUN IN MINUTES IS               25.000
          NORTH LATITUDE (DD MM)              44  3
          WEST LONGITUDE (DD MM)              86 45
          VESSEL'S SPEED (MPH - XX.X)        13.5
          VESSEL'S HEADING (DEGREES)         184
          VESSEL'S DRAFT (FEET)               27
          WIND DIRECTION (DEGREES)           174
          WIND SPEED (KNOTS)                  24
          WAVE DIRECTION (DEGREES)           174
          WAVE HEIGHT (FEET)                   8
REMARKS
MICHIGAN, DWNBND., HEAD SEA
RESET LBI CLOCK

End-of-run message
WIND SPEED M AY BE OFF BY 5 KNTS. (LOW)
```

```
M/V S J CORT FALL TRIALS
          RUN              42           POINT            18
          DATE    01-NOV-79             TIME       11:14:57
          DURATION OF RUN IN MINUTES IS               25.000
          NORTH LATITUDE (DD MM)              43 35
          WEST LONGITUDE (DD MM)              86 50
          VESSEL'S SPEED (MPH - XX.X)        13.5
          VESSEL'S HEADING (DEGREES)         184
          VESSEL'S DRAFT (FEET)               27
          WIND DIRECTION (DEGREES)           185
          WIND SPEED (KNOTS)                  18
          WAVE DIRECTION (DEGREES)           185
          WAVE HEIGHT (FEET)                   8
REMARKS
MICHIGAN, DWNBND., HEAD SEA
PASSING LITTLE SABLE PT.

End-of-run message
```

```
M/V S J CORT FALL TRIALS
          RUN              43           POINT            20
          DATE    01-NOV-79             TIME       07:45:41
          DURATION OF RUN IN MINUTES IS               25.000
          NORTH LATITUDE (DD MM)              43  5
          WEST LONGITUDE (DD MM)              87  0
          VESSEL'S SPEED (MPH - XX.X)        13.8
          VESSEL'S HEADING (DEGREES)         187
          VESSEL'S DRAFT (FEET)               27
          WIND DIRECTION (DEGREES)           228
          WIND SPEED (KNOTS)                  27
          WAVE DIRECTION (DEGREES)           228
          WAVE HEIGHT (FEET)                   8
REMARKS
MICHIGAN, DWNBND., STBD BOW SEA
APPROX. 50 MI. OFF MILWAUKEE

End-of-run message
```

```
M/V S J CORT FALL TRIALS
          RUN              44           POINT            22
          DATE    01-NOV-79             TIME       08:35:58
          DURATION OF RUN IN MINUTES IS               25.000
          NORTH LATITUDE (DD MM)              43  0
          WEST LONGITUDE (DD MM)              87  0
          VESSEL'S SPEED (MPH - XX.X)        13.8
          VESSEL'S HEADING (DEGREES)         187
          VESSEL'S DRAFT (FEET)               27
          WIND DIRECTION (DEGREES)           228
          WIND SPEED (KNOTS)                  27
          WAVE DIRECTION (DEGREES)           228
          WAVE HEIGHT (FEET)                   8
REMARKS
MICHIGAN, DWNBND., STBD BOW SEA
COLLINS ON O'GRAPH

End-of-run message
```

```
M/V S J CORT FALL TRIALS
          RUN              45           POINT            24
          DATE    01-NOV-79             TIME       10:04:42
          DURATION OF RUN IN MINUTES IS               25.000
          NORTH LATITUDE (DD MM)              42 10
          WEST LONGITUDE (DD MM)              87  0
          VESSEL'S SPEED (MPH - XX.X)        13.8
          VESSEL'S HEADING (DEGREES)         187
          VESSEL'S DRAFT (FEET)               27
          WIND DIRECTION (DEGREES)           228
          WIND SPEED (KNOTS)                  27
          WAVE DIRECTION (DEGREES)           228
          WAVE HEIGHT (FEET)                   8
REMARKS
MICHIGAN, DWNBND., STBD BOW SEA
APPROX. 30 MI. OFF CHICAGO

End-of-run message
SHIP SPEED ACTUALLY 12 MPH
```

```
M/V S J CORT FALL TRIALS
          RUN              46           POINT            26
          DATE    01-NOV-79             TIME       13:57:05
          DURATION OF RUN IN MINUTES IS               20.000
          NORTH LATITUDE (DD MM)              47 40
          WEST LONGITUDE (DD MM)              87 10
          VESSEL'S SPEED (MPH - XX.X)         0.0
          VESSEL'S HEADING (DEGREES)         240
          VESSEL'S DRAFT (FEET)               27
          WIND DIRECTION (DEGREES)           230
          WIND SPEED (KNOTS)                  25
          WAVE DIRECTION (DEGREES)           230
          WAVE HEIGHT (FEET)                   6
REMARKS
MICHIGAN, DWNBND., HEAD SEA
LYING OFF BURNS HARBOR

End-of-run message
JUST ENOUGHTURNS ON TO MAINTAIN POSITION
```

```
M/V S J CORT FALL TRIALS
          RUN              47            POINT          28
          DATE    02-NOV-79              TIME     19:08:49
          DURATION OF RUN IN MINUTES IS             25.000
          NORTH LATITUDE (DD MM)              44 30
          WEST LONGITUDE (DD MM)              86 25
          VESSEL'S SPEED (MPH - XX.X)       15.9
          VESSEL'S HEADING (DEGREES)          14
          VESSEL'S DRAFT (FEET)                 16
          WIND DIRECTION (DEGREES)          205
          WIND SPEED (KNOTS)                    23
          WAVE DIRECTION (DEGREES)          205
          WAVE HEIGHT (FEET)                     2
REMARKS
MICHIGAN, UPBND., FOLLOWING SEA
5 MI. OFF POINT BETSIE

End-of-run message
NONE
```

```
M/V S J CORT FALL TRIALS
          RUN              48            POINT          30
          DATE    02-NOV-79              TIME     20:15:23
          DURATION OF RUN IN MINUTES IS             25.000
          NORTH LATITUDE (DD MM)              47  6
          WEST LONGITUDE (DD MM)              85 50
          VESSEL'S SPEED (MPH - XX.X)       15.9
          VESSEL'S HEADING (DEGREES)          34
          VESSEL'S DRAFT (FEET)                 16
          WIND DIRECTION (DEGREES)          255
          WIND SPEED (KNOTS)                    25
          WAVE DIRECTION (DEGREES)          255
          WAVE HEIGHT (FEET)                     5
REMARKS
MICHIGAN, UPBND.,PORT BEAM SEA
WAVE HT. MEASURED AT N. MANITOA, 4 TO 5 FEET

End-of-run message
```

```
M/V S J CORT FALL TRIALS
          RUN              49            POINT          32
          DATE    02-NOV-79              TIME     23:39:07
          DURATION OF RUN IN MINUTES IS             25.000
          NORTH LATITUDE (DD MM)              45 22
          WEST LONGITUDE (DD MM)              85 37
          VESSEL'S SPEED (MPH - XX.X)       15.9
          VESSEL'S HEADING (DEGREES)          34
          VESSEL'S DRAFT (FEET)                 13
          WIND DIRECTION (DEGREES)          200
          WIND SPEED (KNOTS)                    20
          WAVE DIRECTION (DEGREES)          200
          WAVE HEIGHT (FEET)                     4
REMARKS
MICHIGAN, UPBND.,PORT BEAM SEA
WAVE HT. MEASURED AT N. MANITOA, 4 TO 5 FEET

End-of-run message
```

```
M/V S J CORT FALL TRIALS
          RUN              50            POINT          34
          DATE    03-NOV-79              TIME     15:32:2[illegible]
          DURATION OF RUN IN MINUTES IS             25.000
          NORTH LATITUDE (DD MM)              46 45
          WEST LONGITUDE (DD MM)              85 15
          VESSEL'S SPEED (MPH - XX.X)       15.0
          VESSEL'S HEADING (DEGREES)         291
          VESSEL'S DRAFT (FEET)                 16
          WIND DIRECTION (DEGREES)          302
          WIND SPEED (KNOTS)                    10
          WAVE DIRECTION (DEGREES)          302
          WAVE HEIGHT (FEET)                     4
REMARKS
SUPERIOR,UPBND., HEAD SEAS
JUST PAST WHITEFISH PT.

End of-run message
LAST RUN ON TAPE 2
```

```
M/V S J CORT FALL TRIALS                    POINT          4
        RUN          52                     TIME    18:20:01
        DATE    03-NOV-79
        DURATION OF RUN IN MINUTES IS              25.000
        NORTH LATITUDE (DD MM)                  47  5
        WEST LONGITUDE (DD MM)                  86  0
        VESSEL'S SPEED (MPH - XX.X)             15.0
        VESSEL'S HEADING (DEGREES)              291
        VESSEL'S DRAFT (FEET)                   16
        WIND DIRECTION (DEGREES)                298
        WIND SPEED (KNOTS)                      20
        WAVE DIRECTION (DEGREES)                298
        WAVE HEIGHT (FEET)                      4

REMARKS
SUPERIOR,UPBND., HEAD SEAS
OFF CARIBOU ISLAND

End-of-run message
OSCILLOGRAPH WAS RUN SIMULTANEOUSLY DURING THIS RUN
```

```
M/V S J CORT FALL TRIALS                    POINT          6
        RUN          53                     TIME    20:24:03
        DATE    03-NOV-79
        DURATION OF RUN IN MINUTES IS              25.000
        NORTH LATITUDE (DD MM)                  47 10
        WEST LONGITUDE (DD MM)                  86 30
        VESSEL'S SPEED (MPH - XX.X)             15.0
        VESSEL'S HEADING (DEGREES)              291
        VESSEL'S DRAFT (FEET)                   16
        WIND DIRECTION (DEGREES)                290
        WIND SPEED (KNOTS)                      15
        WAVE DIRECTION (DEGREES)                290
        WAVE HEIGHT (FEET)                      4

REMARKS
SUPERIOR,UPBND., HEAD SEAS
WEST OF CARIBOU ISLAND

End-of-run message
OSCILLOGRAPH WAS RUN SIMULTANEOUSLY DURING THIS RUN
```

```
M/V S J CORT FALL TRIALS                    POINT          8
        RUN          54                     TIME    22:43:51
        DATE    03-NOV-79
        DURATION OF RUN IN MINUTES IS              25.000
        NORTH LATITUDE (DD MM)                  47 25
        WEST LONGITUDE (DD MM)                  87 20
        VESSEL'S SPEED (MPH - XX.X)             15.1
        VESSEL'S HEADING (DEGREES)              288
        VESSEL'S DRAFT (FEET)                   17
        WIND DIRECTION (DEGREES)                270
        WIND SPEED (KNOTS)                      18
        WAVE DIRECTION (DEGREES)                270
        WAVE HEIGHT (FEET)                      4

REMARKS
SUPERIOR,UPBND., HEAD SEAS
EAST OF MANITOU ISLAND

End-of-run message
OSCILLOGRAPH WAS RUN SIMULTANEOUSLY DURING THIS RUN
```

```
M/V S J CORT FALL TRIALS                    POINT         10
        RUN          55                     TIME    07:26:34
        DATE    06-NOV-79
        DURATION OF RUN IN MINUTES IS              25.000
        NORTH LATITUDE (DD MM)                  45  8
        WEST LONGITUDE (DD MM)                  86 45
        VESSEL'S SPEED (MPH - XX.X)             14.7
        VESSEL'S HEADING (DEGREES)              205
        VESSEL'S DRAFT (FEET)                   27
        WIND DIRECTION (DEGREES)                0
        WIND SPEED (KNOTS)                      30
        WAVE DIRECTION (DEGREES)                0
        WAVE HEIGHT (FEET)                      2

REMARKS
MICHIGAN,DWN BND.,OFF PT. BETSIE
FOLLOWING SEAS

End-of-run message
DRAFTS FWD 27-2,MIDSHIPS 27-3, AFT 27-4
```

```
M/V S J CORT FALL TRIALS                    POINT         12
        RUN          56                     TIME    13:35:12
        DATE    06-NOV-79
        DURATION OF RUN IN MINUTES IS              30.000
        NORTH LATITUDE (DD MM)                  44 20
        WEST LONGITUDE (DD MM)                  87  0
        VESSEL'S SPEED (MPH - XX.X)             14.7
        VESSEL'S HEADING (DEGREES)              204
        VESSEL'S DRAFT (FEET)                   27
        WIND DIRECTION (DEGREES)                353
        WIND SPEED (KNOTS)                      27
        WAVE DIRECTION (DEGREES)                353
        WAVE HEIGHT (FEET)                      4

REMARKS
MICHIGAN, DWNBND., FOLLOWING SEA
20 MI. OFF RAWLEY PT.

End-of-run message
DATA ON O'GRAPH AS WELL
```

```
M/V S J CORT FALL TRIALS                    POINT         14
        RUN          57                     TIME    15:20:17
        DATE    06-NOV-79
        DURATION OF RUN IN MINUTES IS              30.000
        NORTH LATITUDE (DD MM)                  43 20
        WEST LONGITUDE (DD MM)                  87 10
        VESSEL'S SPEED (MPH - XX.X)             14.7
        VESSEL'S HEADING (DEGREES)              180
        VESSEL'S DRAFT (FEET)                   27
        WIND DIRECTION (DEGREES)                348
        WIND SPEED (KNOTS)                      29
        WAVE DIRECTION (DEGREES)                340
        WAVE HEIGHT (FEET)                      4

REMARKS
MICHIGAN, DWNBND., FOLLOWING SEA
OFF SHEBOYGAN 4 TO 6 FT. SWELL

End-of-run message
RECORDED ON O'GRAPH
```

```
R/V S J CORT FALL TRIALS
            RUN                58          POINT        16
            DATE   06-NOV-79               TIME   20:39:12
            DURATION OF RUN IN MINUTES IS            45.000
            NORTH LATITUDE (DD MM)             42 52
            WEST LONGITUDE (DD MM)             87 10
            VESSEL'S SPEED (MPH - XX.X)        5.0
            VESSEL'S HEADING (DEGREES)         100
            VESSEL'S DRAFT (FEET)               27
            WIND DIRECTION (DEGREES)           320
            WIND SPEED (KNOTS)                  18
            WAVE DIRECTION (DEGREES)           320
            WAVE HEIGHT (FEET)                   6
REMARKS
MICHIGAN, DWNBND., STBD. STERN QUARTERING SEA
OFF MILWAUKEE

End-of-run message
SLOW SPEED RUN
```

```
R/V S J CORT FALL TRIALS
            RUN                59          POINT        18
            DATE   07-NOV-79               TIME   18:08:56
            DURATION OF RUN IN MINUTES IS            45.000
            NORTH LATITUDE (DD MM)             42 52
            WEST LONGITUDE (DD MM)             87 10
            VESSEL'S SPEED (MPH - XX.X)        5.0
            VESSEL'S HEADING (DEGREES)         100
            VESSEL'S DRAFT (FEET)               27
            WIND DIRECTION (DEGREES)           320
            WIND SPEED (KNOTS)                  18
            WAVE DIRECTION (DEGREES)           320
            WAVE HEIGHT (FEET)                   6
REMARKS
MICHIGAN, DWNBND., STBD. STERN QUARTERING SEA
OFF MILWAUKEE

End-of-run message
ADVANCED TAPE
```

```
R/V S J CORT FALL TRIALS
            RUN                59          POINT        18
            DATE   08-NOV-79               TIME   12:51:33
            DURATION OF RUN IN MINUTES IS            25.000
            NORTH LATITUDE (DD MM)             43 47
            WEST LONGITUDE (DD MM)             87 30
            VESSEL'S SPEED (MPH - XX.X)        15.5
            VESSEL'S HEADING (DEGREES)         333
            VESSEL'S DRAFT (FEET)               17
            WIND DIRECTION (DEGREES)           283
            WIND SPEED (KNOTS)                  19
            WAVE DIRECTION (DEGREES)           283
            WAVE HEIGHT (FEET)                   4
REMARKS
MICHIGAN, UPBND.BOW PORT BEAS.
NO. OF SHEBOYGAN, BOUY ON DECK.

End-of-run message
```

```
R/V S J CORT FALL TRIALS
            RUN                60          POINT        20
            DATE   08-NOV 79               TIME   15:01:11
            DURATION OF RUN IN MINUTES IS            25.000
            NORTH LATITUDE (DD MM)             44 10
            WEST LONGITUDE (DD MM)             87 15
            VESSEL'S SPEED (MPH - XX.X)        15.5
            VESSEL'S HEADING (DEGREES)          45
            VESSEL'S DRAFT (FEET)               17
            WIND DIRECTION (DEGREES)           287
            WIND SPEED (KNOTS)                  16
            WAVE DIRECTION (DEGREES)           287
            WAVE HEIGHT (FEET)                   4
REMARKS
MICHIGAN, UPBND.BOW PORT BEAS.
NO. OF SHEBOYGAN, BOUY ON DECK.

End-of-run message
BOUY WAS TURNED OFF DURING THIS RUN.
```

```
R/V S J CORT FALL TRIALS
            RUN                61          POINT        22
            DATE   08-NOV-79               TIME   19:21:43
            DURATION OF RUN IN MINUTES IS            15.000
            NORTH LATITUDE (DD MM)             44 56
            WEST LONGITUDE (DD MM)             86  8
            VESSEL'S SPEED (MPH - XX.X)        15.5
            VESSEL'S HEADING (DEGREES)          50
            VESSEL'S DRAFT (FEET)               17
            WIND DIRECTION (DEGREES)           283
            WIND SPEED (KNOTS)                   8
            WAVE DIRECTION (DEGREES)           283
            WAVE HEIGHT (FEET)                   3
REMARKS
MICHIGAN.UPBND..
OFF SLEEPING BEAR PT., BOUY TEST

End-of-run message
```

```
R/V S J CORT FALL TRIALS
            RUN                62          POINT        24
            DATE   09-NOV-79               TIME   19:50:47
            DURATION OF RUN IN MINUTES IS            25.000
            NORTH LATITUDE (DD MM)             87 10
            WEST LONGITUDE (DD MM)             47 20
            VESSEL'S SPEED (MPH - XX.X)        15.5
            VESSEL'S HEADING (DEGREES)         295
            VESSEL'S DRAFT (FEET)               17
            WIND DIRECTION (DEGREES)            15
            WIND SPEED (KNOTS)                  20
            WAVE DIRECTION (DEGREES)            15
            WAVE HEIGHT (FEET)                   3
REMARKS
SUPERIOR UPBOUND, NIGHT, BEAM SEA
NORTH OF CARIBOU

End-of-run message
NONE
```

```
M/V B J CORT FALL TRIALS
          RUN            63          POINT          26
          DATE    09-NOV-79          TIME     20:14:26
          DURATION OF RUN IN MINUTES IS         25.000
          NORTH LATITUDE (DD MM)          47 25
          WEST LONGITUDE (DD MM)          87 15
          VESSEL'S SPEED (MPH - XX.X)    15.5
          VESSEL'S HEADING (DEGREES)      275
          VESSEL'S DRAFT (FEET)            17
          WIND DIRECTION (DEGREES)         15
          WIND SPEED (KNOTS)               20
          WAVE DIRECTION (DEGREES)         15
          WAVE HEIGHT (FEET)                3
REMARKS
NORTH OF STANNARD ROCK, NIGHT, BEAM SEA
SUPERIOR U/BND

End-of-run message
NONE


M/V B J CORT FALL TRIALS
          RUN            64          POINT          28
          DATE    09-NOV-79          TIME     22:12:51
          DURATION OF RUN IN MINUTES IS         25.000
          NORTH LATITUDE (DD MM)          47 40
          WEST LONGITUDE (DD MM)          87 50
          VESSEL'S SPEED (MPH - XX.X)    15.5
          VESSEL'S HEADING (DEGREES)      275
          VESSEL'S DRAFT (FEET)            17
          WIND DIRECTION (DEGREES)        345
          WIND SPEED (KNOTS)               25
          WAVE DIRECTION (DEGREES)         15
          WAVE HEIGHT (FEET)                5
REMARKS
SUPERIOR UPBND. NORTH OF COPPER HARBOR
30W STBR SEA AT 325 DEG
END TAPE 3
```

```
M/V S J CORT FALL TRIALS
          RUN              66           POINT          3
          DATE    12-NOV-79             TIME    17:33:23
          DURATION OF RUN IN MINUTES IS            75.000
          NORTH LATITUDE (DD MM)              45 55
          WEST LONGITUDE (DD MM)              83 58
          VESSEL'S SPEED (MPH - XX.X)       15.5
          VESSEL'S HEADING (DEGREES)         255
          VESSEL'S DRAFT (FEET)                27
          WIND DIRECTION (DEGREES)           226
          WIND SPEED (KNOTS)                   16
          WAVE DIRECTION (DEGREES)           245
          WAVE HEIGHT (FEET)                    4
REMARKS
HURON DNBND, BOUY ON FOR TEST
4 FT WAVES OFF PORT BOW ALMOST HEAD ON

End-of-run message
BOUY TURNED OFF 20 MINUTES INTO RUN.


M/V S J CORT FALL TRIALS
          RUN              67           POINT          5
          DATE    12-NOV-79             TIME    17:38:43
          DURATION OF RUN IN MINUTES IS            25.000
          NORTH LATITUDE (DD MM)              45 53
          WEST LONGITUDE (DD MM)              84  3
          VESSEL'S SPEED (MPH - XX.X)       15.5
          VESSEL'S HEADING (DEGREES)         255
          VESSEL'S DRAFT (FEET)                27
          WIND DIRECTION (DEGREES)           226
          WIND SPEED (KNOTS)                   16
          WAVE DIRECTION (DEGREES)           245
          WAVE HEIGHT (FEET)                    4
REMARKS
HURON DNBND, 4 FT WAVES OFF PORT BOW

End-of-run message
COURSE CHANGE TO 264 AT 15:30 INTO RUN


M/V S J CORT FALL TRIALS
          RUN              68           POINT          7
          DATE    12-NOV-79             TIME    17:49:09
          DURATION OF RUN IN MINUTES IS            25.000
          NORTH LATITUDE (DD MM)              45 52
          WEST LONGITUDE (DD MM)              84 14
          VESSEL'S SPEED (MPH - XX.X)       15.5
          VESSEL'S HEADING (DEGREES)         264
          VESSEL'S DRAFT (FEET)                27
          WIND DIRECTION (DEGREES)           226
          WIND SPEED (KNOTS)                   16
          WAVE DIRECTION (DEGREES)           245
          WAVE HEIGHT (FEET)                    4
REMARKS
HURON DNBND, 4 FT WAVES OFF PORT BOW

End-of-run message
NONE


M/V S J CORT FALL TRIALS
          RUN              69           POINT          9
          DATE    12-NOV-79             TIME    21:15:52
          DURATION OF RUN IN MINUTES IS            41.667
          NORTH LATITUDE (DD MM)              45 28
          WEST LONGITUDE (DD MM)              85 20
          VESSEL'S SPEED (MPH - XX.X)       15.5
          VESSEL'S HEADING (DEGREES)         279
          VESSEL'S DRAFT (FEET)                27
          WIND DIRECTION (DEGREES)           250
          WIND SPEED (KNOTS)                   20
          WAVE DIRECTION (DEGREES)           250
          WAVE HEIGHT (FEET)                    5
REMARKS
DNBND MICHIGAN, SL-7 CLOCK.

End-of-run message
SAMPLE RATE IS TWO TIMES INDICATED


M/V S J CORT FALL TRIALS
          RUN              70           POINT         11
          DATE    13-NOV-79             TIME    08:42:40
          DURATION OF RUN IN MINUTES IS            25.000
          NORTH LATITUDE (DD MM)              44 15
          WEST LONGITUDE (DD MM)              86 35
          VESSEL'S SPEED (MPH - XX.X)       14.7
          VESSEL'S HEADING (DEGREES)         225
          VESSEL'S DRAFT (FEET)                27
          WIND DIRECTION (DEGREES)           305
          WIND SPEED (KNOTS)                   14
          WAVE DIRECTION (DEGREES)           225
          WAVE HEIGHT (FEET)                    3
REMARKS
MICHIGAN DNBND, WAVE BOUY RUN, PREDOMINANT SEA OUT OF S W
AT 225, SEA IS PREDOMINANTLY SWELL

End-of-run message
STARTED RUN WITH BOUY 2.5 MI AHEAD OF SHIP ENDED RUN WITH
BOUY 4.5 MI BEHIND


M/V S J CORT FALL TRIALS
          RUN              71           POINT         13
          DATE    13-NOV-79             TIME    09:06:44
          DURATION OF RUN IN MINUTES IS            20.000
          NORTH LATITUDE (DD MM)              44 15
          WEST LONGITUDE (DD MM)              86 35
          VESSEL'S SPEED (MPH - XX.X)       14.7
          VESSEL'S HEADING (DEGREES)         225
          VESSEL'S DRAFT (FEET)                27
          WIND DIRECTION (DEGREES)           305
          WIND SPEED (KNOTS)                   14
          WAVE DIRECTION (DEGREES)           225
          WAVE HEIGHT (FEET)                    3
REMARKS
SECOND BOUY RUN , SEA DOWN A LITTLE STILL PREDOMINANT FROM 225
START WITH BOUY 3.5 MI FWD

End-of-run message
BOUY SIGNAL BEING MONITORED BEGANTO MAX OUT TOWARD RUN END - 3.5 MI
```

```
M/V S J CORT FALL TRIALS
          RUN              72          POINT         15
          DATE   15-NOV-79             TIME    18:37:50
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)            46 35
          WEST LONGITUDE (DD MM)            84 45
          VESSEL'S SPEED (MPH - XX.X)     15.3
          VESSEL'S HEADING (DEGREES)       329
          VESSEL'S DRAFT (FEET)              18
          WIND DIRECTION (DEGREES)           5
          WIND SPEED (KNOTS)                 10
          WAVE DIRECTION (DEGREES)           4
          WAVE HEIGHT (FEET)                  4
REMARKS
WHITEFISH BAY, HEAD TO BOW SEA
UPBND, CODE 2

End-of-run message
SEA DIRECTLY OFF STBD BOW (45 DEG), SL-7 NOT ON FOR THIS RUN
```

```
M/V S J CORT FALL TRIALS
          RUN              72          POINT         18
          DATE   15-NOV-79             TIME    19:43:20
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)            46 50
          WEST LONGITUDE (DD MM)            85  5
          VESSEL'S SPEED (MPH - XX.X)     15.5
          VESSEL'S HEADING (DEGREES)       292
          VESSEL'S DRAFT (FEET)              15
          WIND DIRECTION (DEGREES)          12
          WIND SPEED (KNOTS)                 24
          WAVE DIRECTION (DEGREES)          10
          WAVE HEIGHT (FEET)                  3
REMARKS
WEST OF WHITEFISH POINT UPBNDSUPERIOR, BEAM SEA

End-of-run message
SEA BEAM TO BOW
```

```
M/V S J CORT FALL TRIALS
          RUN              73          POINT         17
          DATE   15-NOV-79             TIME    21:11:22
          DURATION OF RUN IN MINUTES IS          33.333
          NORTH LATITUDE (DD MM)            47 10
          WEST LONGITUDE (DD MM)            86 15
          VESSEL'S SPEED (MPH - XX.X)     15.5
          VESSEL'S HEADING (DEGREES)       293
          VESSEL'S DRAFT (FEET)              15
          WIND DIRECTION (DEGREES)          15
          WIND SPEED (KNOTS)                 22
          WAVE DIRECTION (DEGREES)          10
          WAVE HEIGHT (FEET)                  4
REMARKS
CRISP POINT, SUPERIOR UPBND, BEAM SEA

End-of-run message
SL-7 CLOCK USED FOR DATA COLLECTION FREQ'S SHOULD BE OFF
```

```
M/V S J CORT FALL TRIALS
          RUN              74          POINT         19
          DATE   16-NOV-79             TIME    10:02:21
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)            47 22
          WEST LONGITUDE (DD MM)            89  0
          VESSEL'S SPEED (MPH - XX.X)     14.7
          VESSEL'S HEADING (DEGREES)       256
          VESSEL'S DRAFT (FEET)              19
          WIND DIRECTION (DEGREES)         235
          WIND SPEED (KNOTS)                 29
          WAVE DIRECTION (DEGREES)         250
          WAVE HEIGHT (FEET)                  6
REMARKS
SUPERIOR UPBND, FULL BALLAST
WEST OF KEEWEENAW

End-of-run message
SL-7 CLOCK
```

```
M/V S J CORT FALL TRIALS
          RUN              75          POINT         21
          DATE   16-NOV-79             TIME    10:10:57
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)            47 21
          WEST LONGITUDE (DD MM)            89  5
          VESSEL'S SPEED (MPH - XX.X)     14.4
          VESSEL'S HEADING (DEGREES)       256
          VESSEL'S DRAFT (FEET)              19
          WIND DIRECTION (DEGREES)         240
          WIND SPEED (KNOTS)                 29
          WAVE DIRECTION (DEGREES)         250
          WAVE HEIGHT (FEET)                  6
REMARKS
SUPERIOR UPBND, FULL BALLAST
WEST OF KEEWEENAW

End-of-run message
LSI CLOCK
```

```
M/V S J CORT FALL TRIALS
          RUN              76          POINT         23
          DATE   16-NOV-79             TIME    10:19:54
          DURATION OF RUN IN MINUTES IS          50.000
          NORTH LATITUDE (DD MM)            47 15
          WEST LONGITUDE (DD MM)            89 30
          VESSEL'S SPEED (MPH - XX.X)     14.4
          VESSEL'S HEADING (DEGREES)       256
          VESSEL'S DRAFT (FEET)              19
          WIND DIRECTION (DEGREES)         240
          WIND SPEED (KNOTS)                 29
          WAVE DIRECTION (DEGREES)         250
          WAVE HEIGHT (FEET)                  6
REMARKS
SUPERIOR UPBND, FULL BALLAST
WEST OF KEEWEENAW, SL-7 CLOCK

End-of-run message
SL-7 CLOCK RUNNING 2 TIMES NORMAL RATE
```

```
M/V S J CORT FALL TRIALS
          RUN                77          POINT          25
          DATE  . 16-NOV-79              TIME    10:26:41
          DURATION OF RUN IN MINUTES IS           25.000
          NORTH LATITUDE (DD MM)              47 15
          WEST LONGITUDE (DD MM)              89 20
          VESSEL'S SPEED (MPH - XX.X)        14.4
          VESSEL'S HEADING (DEGREES)         256
          VESSEL'S DRAFT (FEET)                19
          WIND DIRECTION (DEGREES)           240
          WIND SPEED (KNOTS)                   29
          WAVE DIRECTION (DEGREES)           250
          WAVE HEIGHT (FEET)                    6
REMARKS
SUPERIOR UPBND, FULL BALLAST
WEST OF KEEWEENAW, LSI CLOCK

End-of-run message .
NONE


M/V S J CORT FALL TRIALS
          RUN                78          POINT          27
          DATE   16-NOV-79               TIME    10:34:09
          DURATION OF RUN IN MINUTES IS           50.000
          NORTH LATITUDE (DD MM)              47 15
          WEST LONGITUDE (DD MM)              89 40
          VESSEL'S SPEED (MPH - XX.X)        14.4
          VESSEL'S HEADING (DEGREES)         256
          VESSEL'S DRAFT (FEET)                19
          WIND DIRECTION (DEGREES)           240
          WIND SPEED (KNOTS)                   29
          WAVE DIRECTION (DEGREES)           250
          WAVE HEIGHT (FEET)                    6
REMARKS
SUPERIOR UPBND, FULL BALLAST
WEST OF KEEWEENAW, SL-7 CLOCK

End-of-run message
SL-7 CLOCK RUNNING TWO TIMES NORMAL RATE

END TAPE ? 4
```

```
M/V S J CORT FALL TRIALS
        RUN              80          POINT          3
        DATE    16-NOV-79            TIME    12:34:00
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)            47 10
        WEST LONGITUDE (DD MM)            89 55
        VESSEL'S SPEED (MPH - XX.X)     14.4
        VESSEL'S HEADING (DEGREES)        256
        VESSEL'S DRAFT (FEET)              20
        WIND DIRECTION (DEGREES)          240
        WIND SPEED (KNOTS)                 29
        WAVE DIRECTION (DEGREES)          245
        WAVE HEIGHT (FEET)                  6
REMARKS
UPBND SUPERIOR WEST OF KEEWEENAW
LSI CLOCK

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN              81          POINT          5
        DATE    16-NOV-79            TIME    12:47:34
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)            47 15
        WEST LONGITUDE (DD MM)            90 15
        VESSEL'S SPEED (MPH - XX.X)     14.4
        VESSEL'S HEADING (DEGREES)        256
        VESSEL'S DRAFT (FEET)              20
        WIND DIRECTION (DEGREES)          240
        WIND SPEED (KNOTS)                 29
        WAVE DIRECTION (DEGREES)          245
        WAVE HEIGHT (FEET)                  6
REMARKS
UPBND SUPERIOR WEST OF KEEWEENAW
LSI CLOCK

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN              82          POINT          7
        DATE    16-NOV-79            TIME    12:54:31
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)            47 15
        WEST LONGITUDE (DD MM)            90 20
        VESSEL'S SPEED (MPH - XX.X)     14.4
        VESSEL'S HEADING (DEGREES)        256
        VESSEL'S DRAFT (FEET)              20
        WIND DIRECTION (DEGREES)          240
        WIND SPEED (KNOTS)                 25
        WAVE DIRECTION (DEGREES)          250
        WAVE HEIGHT (FEET)                  6
REMARKS
UPBND SUPERIOR WEST OF KEEWEENAW
LSI CLOCK

End-of-run message
S-GRAPH TRACE MADE OF RUN
```

```
M/V S J CORT FALL TRIALS
        RUN              83          POINT          9
        DATE    16-NOV-79            TIME    13:20:46
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)            47  8
        WEST LONGITUDE (DD MM)            90 38
        VESSEL'S SPEED (MPH - XX.X)     14.2
        VESSEL'S HEADING (DEGREES)        245
        VESSEL'S DRAFT (FEET)              20
        WIND DIRECTION (DEGREES)          245
        WIND SPEED (KNOTS)                 25
        WAVE DIRECTION (DEGREES)          250
        WAVE HEIGHT (FEET)                  6
REMARKS
UPBND SUPERIOR, NORTH OF APOSTLES, HEAD SEA
LSI CLOCK

End-of-run message
SEA DIMINISHING, WAVES 4-5 FT.
```

```
M/V S J CORT FALL TRIALS
        RUN              84          POINT         11
        DATE    16-NOV-79            TIME    13:26:24
        DURATION OF RUN IN MINUTES IS          50.000
        NORTH LATITUDE (DD MM)            47  6
        WEST LONGITUDE (DD MM)            90 35
        VESSEL'S SPEED (MPH - XX.X)     14.2
        VESSEL'S HEADING (DEGREES)        245
        VESSEL'S DRAFT (FEET)              20
        WIND DIRECTION (DEGREES)          245
        WIND SPEED (KNOTS)                 25
        WAVE DIRECTION (DEGREES)          250
        WAVE HEIGHT (FEET)                  4
REMARKS
UPBND SUPERIOR, NORTH OF APOSTLES, HEAD SEA
SL-7 CLOCK

End-of-run message
WAVES 4-5 FT.
```

```
M/V S J CORT FALL TRIALS
        RUN              85          POINT         13
        DATE    16-NOV-79            TIME    13:39:05
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)            46 55
        WEST LONGITUDE (DD MM)            91 20
        VESSEL'S SPEED (MPH - XX.X)     14.2
        VESSEL'S HEADING (DEGREES)        245
        VESSEL'S DRAFT (FEET)              20
        WIND DIRECTION (DEGREES)          245
        WIND SPEED (KNOTS)                 25
        WAVE DIRECTION (DEGREES)          250
        WAVE HEIGHT (FEET)                  3
REMARKS
UPBND SUPERIOR,WEST OF APOSTLES, HEAD SEA
LSI CLOCK

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN                86          POINT         15
        DATE    16-NOV-79              TIME    13:45:29
        DURATION OF RUN IN MINUTES IS            50.000
        NORTH LATITUDE (DD MM)              44 50
        WEST LONGITUDE (DD MM)              91 12
        VESSEL'S SPEED (MPH - XX.X)       14.2
        VESSEL'S HEADING (DEGREES)         245
        VESSEL'S DRAFT (FEET)               20
        WIND DIRECTION (DEGREES)           245
        WIND SPEED (KNOTS)                  25
        WAVE DIRECTION (DEGREES)           250
        WAVE HEIGHT (FEET)                   3
REMARKS
UPBND SUPERIOR,WEST OF APOSTLES, HEAD SEA
SL-7 CLO'K

End-of-run message
SEA DIMI..SHING, 2-3 FT. WAVES
```

```
M/V S J CORT FALL TRIALS
        RUN                87          POINT         17
        DATE    16-NOV-79              TIME    14:30:47
        DURATION OF RUN IN MINUTES IS            50.000
        NORTH LATITUDE (DD MM)              46 58
        WEST LONGITUDE (DD MM)              91 15
        VESSEL'S SPEED (MPH - XX.X)       14.2
        VESSEL'S HEADING (DEGREES)         245
        VESSEL'S DRAFT (FEET)               20
        WIND DIRECTION (DEGREES)           245
        WIND SPEED (KNOTS)                  25
        WAVE DIRECTION (DEGREES)           250
        WAVE HEIGHT (FEET)                   2
REMARKS
SUPERIOR UPBND, OFF BARK POINT
LSI CLOCK

End-of-run message
RUN ABORTED AFTER 15 MIN, REQUESTED DURATION TOO LONG, DATA GOOD
```

```
M/V S J CORT FALL TRIALS
        RUN                88          POINT         19
        DATE    16 NOV-79              TIME    14:38:58
        DURATION OF RUN IN MINUTES IS            50.000
        NORTH LATITUDE (DD MM)              46 53
        WEST LONGITUDE (DD MM)              91 30
        VESSEL'S SPEED (MPH - XX.X)       14.2
        VESSEL'S HEADING (DEGREES)         245
        VESSEL'S DRAFT (FEET)               20
        WIND DIRECTION (DEGREES)           245
        WIND SPEED (KNOTS)                  25
        WAVE DIRECTION (DEGREES)           250
        WAVE HEIGHT (FEET)                   2
REMARKS
SUPERIOR UPBND,APPROACHING SUPERIOR ORE DOCKS
SL-7 CLOCK

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN                89          POINT         21
        DATE    18-NOV-79              TIME    15:03:52
        DURATION OF RUN IN MINUTES IS            25.000
        NORTH LATITUDE (DD MM)              47 10
        WEST LONGITUDE (DD MM)              P5  0
        VESSEL'S SPEED (MPH - XX.X)       1..7
        VESSEL'S HEADING (DEGREES)         .14
        VESSEL'S DRAFT (FEET)               27
        WIND DIRECTION (DEGREES)           138
        WIND SPEED (KNOTS)                  16
        WAVE DIRECTION (DEGREES)           120
        WAVE HEIGHT (FEET)                   3
REMARKS
SUPERIOR DNBND, NORTH OF CARIBOU, HEAD SEA
LSI CLOCK

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN                90          POINT         23
        DATE    18-NOV-79              TIME    15:22:45
        DURATION OF RUN IN MINUTES IS            25.000
        NORTH LATITUDE (DD MM)              46 55
        WEST LONGITUDE (DD MM)              85 25
        VESSEL'S SPEED (MPH - XX.X)       14.7
        VESSEL'S HEADING (DEGREES)         114
        VESSEL'S DRAFT (FEET)               27
        WIND DIRECTION (DEGREES)           138
        WIND SPEED (KNOTS)                  16
        WAVE DIRECTION (DEGREES)           120
        WAVE HEIGHT (FEET)                   3
REMARKS
SUPERIOR UPBND, NORTH OF CRISP POINT, HEAD SEA
LSI CLOCK

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN                91          POINT         25
        DATE    20-NOV-79              TIME    22:47:03
        DURATION OF RUN IN MINUTES IS            25.000
        NORTH LATITUDE (DD MM)              44 30
        WEST LONGITUDE (DD MM)              87  0
        VESSEL'S SPEED (MPH - XX.X)       14.7
        VESSEL'S HEADING (DEGREES)         2:6
        VESSEL'S DRAFT (FEET)               27
        WIND DIRECTION (DEGREES)           235
        WIND SPEED (KNOTS)                  12
        WAVE DIRECTION (DEGREES)           220
        WAVE HEIGHT (FEET)                   3
REMARKS
SUPERIOR DNBND, HEAD SEA,EAST OF STURGEON BAY, 3 FT WAVES
LSI CLOCK

End-of-run message
```

```
SJ CORT TRIALS--CHECKOUT RUNS
          RUN              21           POINT          25
          DATE    30-NOV-79             TIME     18:28:09
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)               47 20
          WEST LONGITUDE (DD MM)               89 55
          VESSEL'S SPEED (MPH - XX.X)        14.9
          VESSEL'S HEADING (DEGREES)           76
          VESSEL'S DRAFT (FEET)                 27
          WIND DIRECTION (DEGREES)            338
          WIND SPEED (KNOTS)                    18
          WAVE DIRECTION (DEGREES)            350
          WAVE HEIGHT (FEET)                     3
REMARKS
SUPERIOR BNDND, BEAM SEA, NORTH OF OUTER  ISLAND
SL7 INOPERATIVE

End-of-run message
END OF TAPE 5
```

```
M/V S J CORT FALL TRIALS
        RUN              93          POINT          2
        DATE    04-DEC-79            TIME    19:42:49
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)          84  8
        WEST LONGITUDE (DD MM)          45 53
        VESSEL'S SPEED (MPH - XX.X)    15.4
        VESSEL'S HEADING (DEGREES)       74
        VESSEL'S DRAFT (FEET)            15
        WIND DIRECTION (DEGREES)        198
        WIND SPEED (KNOTS)               22
        WAVE DIRECTION (DEGREES)        198
        WAVE HEIGHT (FEET)                3
REMARKS
HURON UPBND,BOUY ON FOR CHECK
LSI CLOCK

End-of-run message
BOUY NOT ON
```

```
M/V S J CORT FALL TRIALS
        RUN              94          POINT          4
        DATE    05-DEC-79            TIME    08:32:58
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)          85 50
        WEST LONGITUDE (DD MM)          44 58
        VESSEL'S SPEED (MPH - XX.X)    14.2
        VESSEL'S HEADING (DEGREES)      292
        VESSEL'S DRAFT (FEET)            15
        WIND DIRECTION (DEGREES)        215
        WIND SPEED (KNOTS)               24
        WAVE DIRECTION (DEGREES)        230
        WAVE HEIGHT (FEET)                4
REMARKS
SUPERIOR UPBND, SEA FORM BOW SPREDOMINANT , WIND FROM BEAM KNOCKING Down
SEA SOMEWHAT

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN              95          POINT          6
        DATE    05-DEC-79            TIME    09:27:12
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)          84 13
        WEST LONGITUDE (DD MM)          47 12
        VESSEL'S SPEED (MPH - XX.X)    15.5
        VESSEL'S HEADING (DEGREES)      284
        VESSEL'S DRAFT (FEET)            15
        WIND DIRECTION (DEGREES)        210
        WIND SPEED (KNOTS)               24
        WAVE DIRECTION (DEGREES)        230
        WAVE HEIGHT (FEET)                5
REMARKS
SUPERIOR UPBOUND, BEAM SEA, CODE 2
LSI CLOCK

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN              96          POINT          8
        DATE    05-DEC-79            TIME    09:57:50
        DURATION OF RUN IN MINUTES IS          25.060
        NORTH LATITUDE (DD MM)          86 30
        WEST LONGITUDE (DD MM)          47 15
        VESSEL'S SPEED (MPH - XX.X)    15.5
        VESSEL'S HEADING (DEGREES)      284
        VESSEL'S DRAFT (FEET)            15
        WIND DIRECTION (DEGREES)        210
        WIND SPEED (KNOTS)               24
        WAVE DIRECTION (DEGREES)        230
        WAVE HEIGHT (FEET)                4
REMARKS
SUPERIOR UPBOUND, BEAM SEA, CODE 2
S-W OF CARIBOU

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN              97          POINT         10
        DATE    05-DEC-79            TIME    10:11:42
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)          84 40
        WEST LONGITUDE (DD MM)          47 20
        VESSEL'S SPEED (MPH - XX.X)    15.5
        VESSEL'S HEADING (DEGREES)      284
        VESSEL'S DRAFT (FEET)            15
        WIND DIRECTION (DEGREES)        210
        WIND SPEED (KNOTS)               24
        WAVE DIRECTION (DEGREES)        230
        WAVE HEIGHT (FEET)                4
REMARKS
SUPERIOR UPBOUND, BEAM SEA, CODE 2
S-W OF CARIBOU

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN              98          POINT         12
        DATE    05-DEC-79            TIME    12:27:15
        DURATION OF RUN IN MINUTES IS          25.000
        NORTH LATITUDE (DD MM)          87 20
        WEST LONGITUDE (DD MM)          47 25
        VESSEL'S SPEED (MPH - XX.X)    15.5
        VESSEL'S HEADING (DEGREES)      290
        VESSEL'S DRAFT (FEET)            17
        WIND DIRECTION (DEGREES)        260
        WIND SPEED (KNOTS)               19
        WAVE DIRECTION (DEGREES)        260
        WAVE HEIGHT (FEET)                4
REMARKS
SUPERIOR, UPBND., BOW SEA, CODE 3
7 MI. OFF MANITOU ISLE

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN             99          POINT          14
        DATE    05-DEC-79           TIME     14:11:19
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)             88  0
        WEST LONGITUDE (DD MM)             47 35
        VESSEL'S SPEED (MPH - XX.X)      11.6
        VESSEL'S HEADING (DEGREES)        270
        VESSEL'S DRAFT (FEET)               18
        WIND DIRECTION (DEGREES)          270
        WIND SPEED (KNOTS)                  15
        WAVE DIRECTION (DEGREES)          270
        WAVE HEIGHT (FEET)                   5
REMARKS
SUPERIOR, UPBND., HEAD SEA, CODE 3
7 MI. OFF KEWEENAW PENINSULA , PT. OUTBD. ENGINE CLEARED

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN             100         POINT          16
        DATE    05-DEC-79           TIME     14:16:27
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)             88  5
        WEST LONGITUDE (DD MM)             47 35
        VESSEL'S SPEED (MPH - XX.X)      11.6
        VESSEL'S HEADING (DEGREES)        270
        VESSEL'S DRAFT (FEET)               17
        WIND DIRECTION (DEGREES)          270
        WIND SPEED (KNOTS)                  15
        WAVE DIRECTION (DEGREES)          270
        WAVE HEIGHT (FEET)                   5
REMARKS
SUPERIOR, UPBND., HEAD SEA, CODE 3
7 MI. OFF KEWEENAW PENINSULA , PT. OUTBD. ENGINE CLEARED

End-of-run message
SL-7 INOPERATIVE
```

```
M/V S J CORT FALL TRIALS
        RUN             101         POINT          18
        DATE    05-DEC-79           TIME     14:53:38
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)             88 20
        WEST LONGITUDE (DD MM)             47 30
        VESSEL'S SPEED (MPH - XX.X)      11.6
        VESSEL'S HEADING (DEGREES)        260
        VESSEL'S DRAFT (FEET)               19
        WIND DIRECTION (DEGREES)          350
        WIND SPEED (KNOTS)                  27
        WAVE DIRECTION (DEGREES)          240
        WAVE HEIGHT (FEET)                   5
REMARKS
SUPERIOR, UPBND., PORT BOW SEA CODE 3
OFF KEWEENAW PENINSULA

End-of-run message
PREDOMINANT SEA FROM PT BOW BEING KNOCKED DN BY STBD GALE
BECOMING CONFUSED
```

```
M/V S J CORT FALL TRIALS
        RUN             102         POINT          20
        DATE    05-DEC-79           TIME     18:27:52
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)             88 55
        WEST LONGITUDE (DD MM)             47 25
        VESSEL'S SPEED (MPH - XX.X)      11.6
        VESSEL'S HEADING (DEGREES)        260
        VESSEL'S DRAFT (FEET)               19
        WIND DIRECTION (DEGREES)          350
        WIND SPEED (KNOTS)                  27
        WAVE DIRECTION (DEGREES)          240
        WAVE HEIGHT (FEET)                   6
REMARKS
SUPERIOR, UPBND., PORT BOW SEA
OFF KEWEENAW PENINSULA

End-of-run message
SEABECOMING MORE CONFUSED FROMSTBD BEAM WIND
```

```
M/V S J CORT FALL TRIALS
        RUN             103         POINT          22
        DATE    05-DEC-79           TIME     16:17:03
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)             88 50
        WEST LONGITUDE (DD MM)             47 25
        VESSEL'S SPEED (MPH - XX.X)      15.5
        VESSEL'S HEADING (DEGREES)        260
        VESSEL'S DRAFT (FEET)               19
        WIND DIRECTION (DEGREES)          340
        WIND SPEED (KNOTS)                  28
        WAVE DIRECTION (DEGREES)          240
        WAVE HEIGHT (FEET)                   6
REMARKS
SUPERIOR, UPBND., PORT BOW SEA CODE 3
ALL ENGINES BACK ON LINE

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN             104         POINT          24
        DATE    05-DEC-79           TIME     18:28:04
        DURATION OF RUN IN MINUTES IS           25.000
        NORTH LATITUDE (DD MM)             89 40
        WEST LONGITUDE (DD MM)             47 45
        VESSEL'S SPEED (MPH - XX.X)      13.3
        VESSEL'S HEADING (DEGREES)        260
        VESSEL'S DRAFT (FEET)               17
        WIND DIRECTION (DEGREES)          315
        WIND SPEED (KNOTS)                  16
        WAVE DIRECTION (DEGREES)          240
        WAVE HEIGHT (FEET)                   6
REMARKS
SUPERIOR UPBND, BEAM SEA

End-of-run message
SEA PRED STBD BOW
```

M/V S J CORT FALL TRIALS

RUN	105	POINT	26
DATE	05-DEC-79	TIME	19:04:01
DURATION OF RUN IN MINUTES IS			25.000
NORTH LATITUDE (DD MM)		89 55	
WEST LONGITUDE (DD MM)		47 50	
VESSEL'S SPEED (MPH - XX.X)		13.3	
VESSEL'S HEADING (DEGREES)		260	
VESSEL'S DRAFT (FEET)		17	
WIND DIRECTION (DEGREES)		315	
WIND SPEED (KNOTS)		16	
WAVE DIRECTION (DEGREES)		310	
WAVE HEIGHT (FEET)		3	

REMARKS
SUPERIOR UPBND, BOW SEA

End-of-run message

M/V S J CORT FALL TRIALS

RUN	106	POINT	28
DATE	07-DEC-79	TIME	10:54:46
DURATION OF RUN IN MINUTES IS			25.000
NORTH LATITUDE (DD MM)		90 32	
WEST LONGITUDE (DD MM)		47 40	
VESSEL'S SPEED (MPH - XX.X)		14.0	
VESSEL'S HEADING (DEGREES)		69	
VESSEL'S DRAFT (FEET)		27	
WIND DIRECTION (DEGREES)		350	
WIND SPEED (KNOTS)		24	
WAVE DIRECTION (DEGREES)		310	
WAVE HEIGHT (FEET)		3	

REMARKS
SUPERIOR DNBND, BEAM SEA , LITTLE FETCH

End-of-run message

M/V S J CORT FALL TRIALS

RUN	107	POINT	30
DATE	07-DEC-79	TIME	17:07:52
DURATION OF RUN IN MINUTES IS			25.000
NORTH LATITUDE (DD MM)		88 10	
WEST LONGITUDE (DD MM)		47 45	
VESSEL'S SPEED (MPH - XX.X)		15.1	
VESSEL'S HEADING (DEGREES)		80	
VESSEL'S DRAFT (FEET)		27	
WIND DIRECTION (DEGREES)		35	
WIND SPEED (KNOTS)		29	
WAVE DIRECTION (DEGREES)		310	
WAVE HEIGHT (FEET)		4	

REMARKS
SUPERIOR DNBND,NORTH OF KEWEENAW
CONFUSED BEAM/BOW SEA BOW PREDOMINANT

End-of-run message
RUN ABORTED FOR 30 DEG COURSE CHANGE DURING RUN

M/V S J CORT FALL TRIALS

RUN	108	POINT	32
DATE	07-DEC-79	TIME	17:29:51
DURATION OF RUN IN MINUTES IS			25.000
NORTH LATITUDE (DD MM)		90 5	
WEST LONGITUDE (DD MM)		47 42	
VESSEL'S SPEED (MPH - XX.X)		15.1	
VESSEL'S HEADING (DEGREES)		110	
VESSEL'S DRAFT (FEET)		27	
WIND DIRECTION (DEGREES)		333	
WIND SPEED (KNOTS)		29	
WAVE DIRECTION (DEGREES)		0	
WAVE HEIGHT (FEET)		4	

REMARKS
SUPERIOR NORTH OF EAGLE HARBORDNBND, BEAM SEA

End-of-run message

M/V S J CORT FALL TRIALS

RUN	109	POINT	34
DATE	09-DEC-79	TIME	03:18:50
DURATION OF RUN IN MINUTES IS			25.000
NORTH LATITUDE (DD MM)		85 45	
WEST LONGITUDE (DD MM)		45 53	
VESSEL'S SPEED (MPH - XX.X)		13.5	
VESSEL'S HEADING (DEGREES)		245	
VESSEL'S DRAFT (FEET)		27	
WIND DIRECTION (DEGREES)		237	
WIND SPEED (KNOTS)		28	
WAVE DIRECTION (DEGREES)		237	
WAVE HEIGHT (FEET)		6	

REMARKS
MICHIGAN DNBND
WAVE EST BASED ON WIND BLOW AND LIGHT OBS

End-of-run message
RUNABORTED , COURSE CHANGE TO 205
END OF TAPE 6

```
M/V S J CORT FALL TRIALS
          RUN              110             POINT            3
          DATE    09-DEC-79                TIME      04:01:01
          DURATION OF RUN IN MINUTES IS                25.000
          NORTH LATITUDE (DD MM)               85 50
          WEST LONGITUDE (DD MM)               47 38
          VESSEL'S SPEED (MPH - XX.X)         15.1
          VESSEL'S HEADING (DEGREES)           205
          VESSEL'S DRAFT (FEET)                 27
          WIND DIRECTION (DEGREES)             240
          WIND SPEED (KNOTS)                    35
          WAVE DIRECTION (DEGREES)               0
          WAVE HEIGHT (FEET)                     6
REMARKS
MICHIGAN DNBND, BOW SEA

End-of-run message
```

```
M/V S J CORT FALL TRIALS
          RUN              111             POINT            5
          DATE    09-DEC-79                TIME      04:24:19
          DURATION OF RUN IN MINUTES IS                25.000
          NORTH LATITUDE (DD MM)               84 15
          WEST LONGITUDE (DD MM)               45 30
          VESSEL'S SPEED (MPH - XX.X)         13.5
          VESSEL'S HEADING (DEGREES)           207
          VESSEL'S DRAFT (FEET)                 27
          WIND DIRECTION (DEGREES)             240
          WIND SPEED (KNOTS)                    35
          WAVE DIRECTION (DEGREES)               0
          WAVE HEIGHT (FEET)                     7
REMARKS
MICHIGAN DNBND, BOW SEA

End-of-run message
```

```
M/V S J CORT FALL TRIALS
          RUN              112             POINT            7
          DATE    09-DEC-79                TIME      04:51:22
          DURATION OF RUN IN MINUTES IS                25.000
          NORTH LATITUDE (DD MM)               86 20
          WEST LONGITUDE (DD MM)               45 20
          VESSEL'S SPEED (MPH - XX.X)         13.5
          VESSEL'S HEADING (DEGREES)           207
          VESSEL'S DRAFT (FEET)                 27
          WIND DIRECTION (DEGREES)             240
          WIND SPEED (KNOTS)                    30
          WAVE DIRECTION (DEGREES)             240
          WAVE HEIGHT (FEET)                     7
REMARKS
MICHIGAN DNBND, BOW SEA
WAVE DIRECTION FOR RUNS 110 - 111 = 240
```

```
M/V S J CORT FALL TRIALS
          RUN              113             POINT            9
          DATE    09-DEC-77                TIME      12:28:41
          DURATION OF RUN IN MINUTES IS                25.000
          NORTH LATITUDE (DD MM)               84 35
          WEST LONGITUDE (DD MM)               44 15
          VESSEL'S SPEED (MPH - XX.X)         12.5
          VESSEL'S HEADING (DEGREES)           187
          VESSEL'S DRAFT (FEET)                 27
          WIND DIRECTION (DEGREES)             210
          WIND SPEED (KNOTS)                    25
          WAVE DIRECTION (DEGREES)               0
          WAVE HEIGHT (FEET)                     7
REMARKS
MICHIGAN DNBND, HEAD/BOW SEA, HEAD PRED

End-of-run message
```

```
M/V S J CORT FALL TRIALS
          RUN              114             POINT           11
          DATE    09-DEC-79                TIME      12:49:10
          DURATION OF RUN IN MINUTES IS                25.000
          NORTH LATITUDE (DD MM)               84 34
          WEST LONGITUDE (DD MM)               44 15
          VESSEL'S SPEED (MPH - XX.X)         12.5
          VESSEL'S HEADING (DEGREES)           187
          VESSEL'S DRAFT (FEET)                 27
          WIND DIRECTION (DEGREES)             238
          WIND SPEED (KNOTS)                    20
          WAVE DIRECTION (DEGREES)             212
          WAVE HEIGHT (FEET)                     7
REMARKS
MICHIGAN DNBND, HEAD/BOW SEA, HEAD PRED
WAVE DIRECTION FOR 113 = 212

End-of-run message
```

```
M/V S J CORT FALL TRIALS
          RUN              115             POINT           13
          DATE    07-DEC-79                TIME      13:37:13
          DURATION OF RUN IN MINUTES IS                25.000
          NORTH LATITUDE (DD MM)               87 15
          WEST LONGITUDE (DD MM)               43 45
          VESSEL'S SPEED (MPH - XX.X)         13.5
          VESSEL'S HEADING (DEGREES)           187
          VESSEL'S DRAFT (FEET)                 27
          WIND DIRECTION (DEGREES)             247
          WIND SPEED (KNOTS)                    18
          WAVE DIRECTION (DEGREES)             212
          WAVE HEIGHT (FEET)                     4
REMARKS
MICHIGAN DNBND, HEAD/BOW SEA, HEAD PRED
```

```
M/V S J CORT FALL TRIALS
        RUN            116          POINT        15
        DATE    09-DEC-79           TIME   13:42:01
        DURATION OF RUN IN MINUTES IS        25.000
        NORTH LATITUDE (DD MM)             87  7
        WEST LONGITUDE (DD MM)             44  8
        VESSEL'S SPEED (MPH - XX.X)       13.5
        VESSEL'S HEADING (DEGREES)         189
        VESSEL'S DRAFT (FEET)               27
        WIND DIRECTION (DEGREES)           247
        WIND SPEED (KNOTS)                  10
        WAVE DIRECTION (DEGREES)           212
        WAVE HEIGHT (FEET)                   4
REMARKS
MICHIGAN DNBND, HEAD/BOW SEA, HEAD PREP
SEA DYING

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN            117          POINT        17
        DATE    09-DEC-79           TIME   15:04:54
        DURATION OF RUN IN MINUTES IS        25.000
        NORTH LATITUDE (DD MM)             87 13
        WEST LONGITUDE (DD MM)             43 20
        VESSEL'S SPEED (MPH - XX.X)       13.5
        VESSEL'S HEADING (DEGREES)         188
        VESSEL'S DRAFT (FEET)               27
        WIND DIRECTION (DEGREES)           263
        WIND SPEED (KNOTS)                  14
        WAVE DIRECTION (DEGREES)           198
        WAVE HEIGHT (FEET)                   3
REMARKS
MICHIGAN DNBND,HEAD SEA
2-3 FT SWELL

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN            118          POINT        19
        DATE    09-DEC-79           TIME   15:48:15
        DURATION OF RUN IN MINUTES IS        25.000
        NORTH LATITUDE (DD MM)             86 52
        WEST LONGITUDE (DD MM)             43  9
        VESSEL'S SPEED (MPH - XX.X)       14.2
        VESSEL'S HEADING (DEGREES)         189
        VESSEL'S DRAFT (FEET)               27
        WIND DIRECTION (DEGREES)           289
        WIND SPEED (KNOTS)                  10
        WAVE DIRECTION (DEGREES)           198
        WAVE HEIGHT (FEET)                   3
REMARKS
MICHIGAN DNBND,HEAD SEA
2-3 FT SWELL

End-of-run message
```

```
M/V S J CORT FALL TRIALS
        RUN            119          POINT        21
        DATE    09-DEC-79           TIME   15:50:07
        DURATION OF RUN IN MINUTES IS        25.000
        NORTH LATITUDE (DD MM)             86 52
        WEST LONGITUDE (DD MM)             43  9
        VESSEL'S SPEED (MPH - XX.X)       14.2
        VESSEL'S HEADING (DEGREES)         189
        VESSEL'S DRAFT (FEET)               27
        WIND DIRECTION (DEGREES)           289
        WIND SPEED (KNOTS)                  10
        WAVE DIRECTION (DEGREES)           198
        WAVE HEIGHT (FEET)                   3
REMARKS
MICHIGAN DNBND,HEAD SEA
2-3 FT SWELL
END TAPE 7
```

APPENDIX D

Maindeck and bottom strain gauge time histories for the 8 conditions listed in Table 2.

Notes: (a) DT in Run # stands for DTNSRDC

(b) 1800 second plot is total run data plotted on single graph

(c) 550 seconds plot is the first part of each run

(d) Note the assymmetries in the maindeck data. The cause of this is the subject of further investigations

(e) Approximate engineering conversion units:

Maindeck	19.52 psi/count
Bottom	19.21 psi/count

CONDITION 1

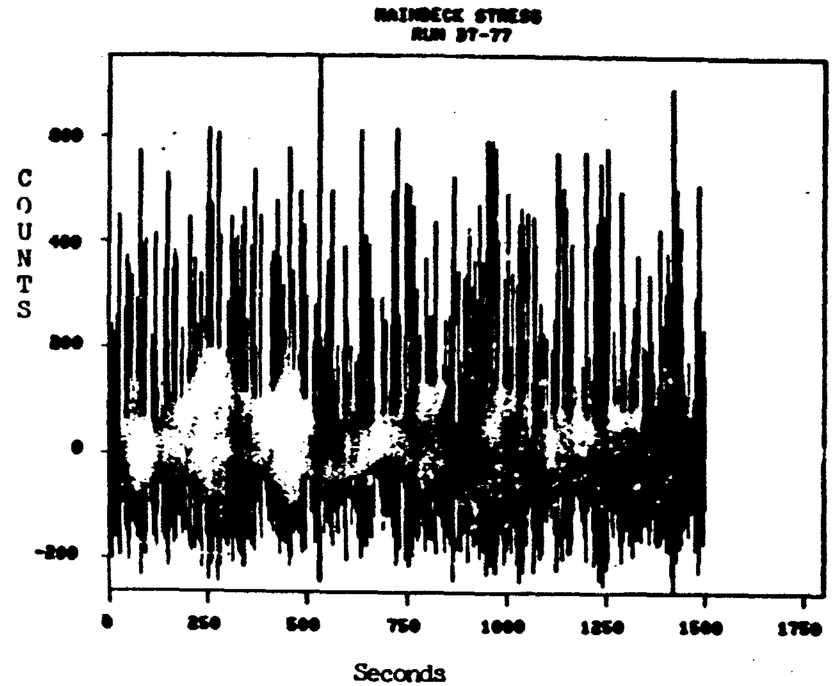
M/V S J CORT FALL TRIALS

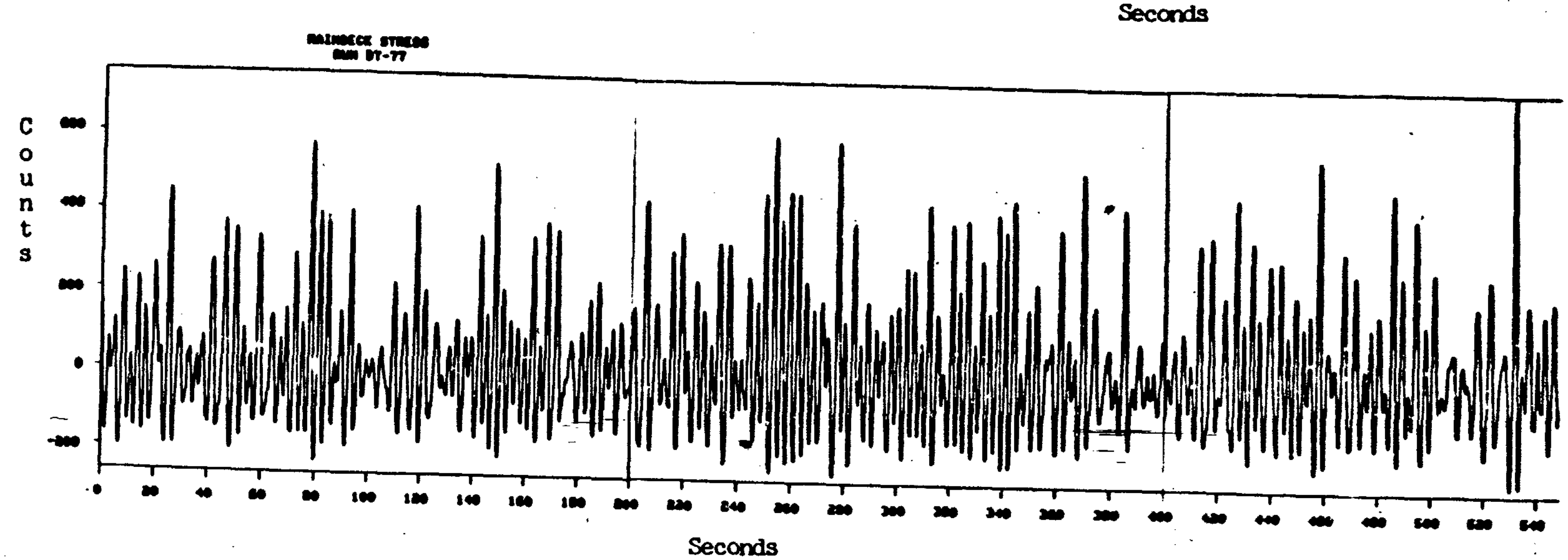
RUN	77	POINT	25
DATE	14-NOV-79	TIME	10:26:41
DURATION OF RUN IN MINUTES IS			25.000
NORTH LATITUDE (DD MM)	47 15		
WEST LONGITUDE (DD MM)	89 20		
VESSEL'S SPEED (MPH - XX.X)	14.4		
VESSEL'S HEADING (DEGREES)	236		
VESSEL'S DRAFT (FEET)	19		
WIND DIRECTION (DEGREES)	240		
WIND SPEED (KNOTS)	29		
WAVE DIRECTION (DEGREES)	250		
WAVE HEIGHT (FEET)	6		

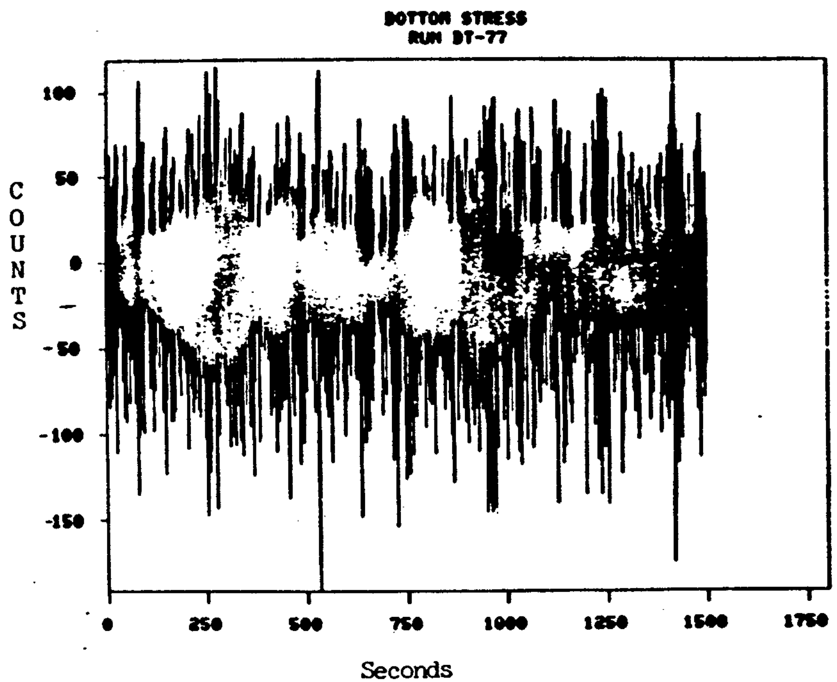
REMARKS
SUPERIOR UPBND, FULL BALLAST
WEST OF KEEWEENAW, LSI CLOCK

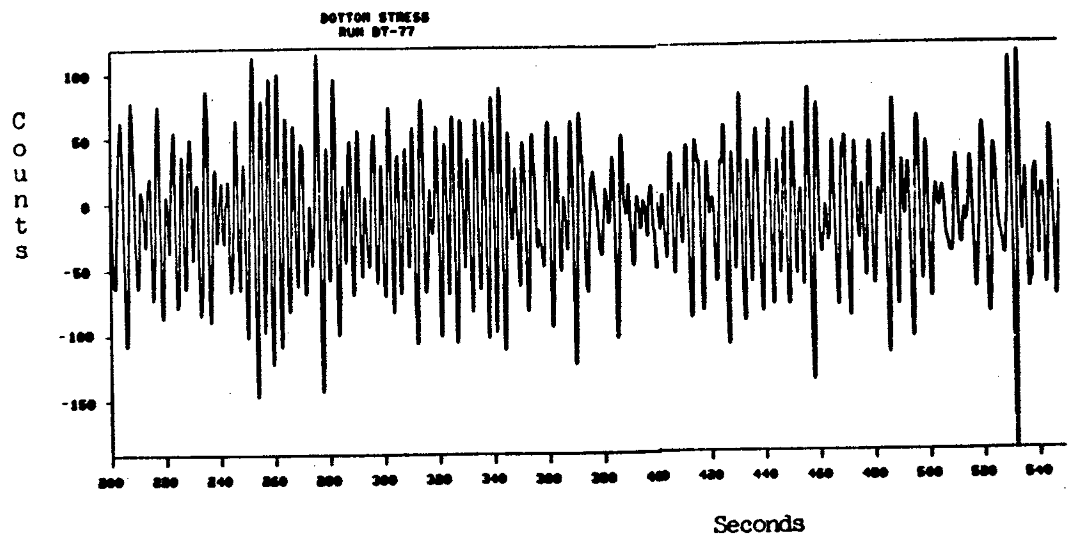
End-of-run message
NONE

D-2





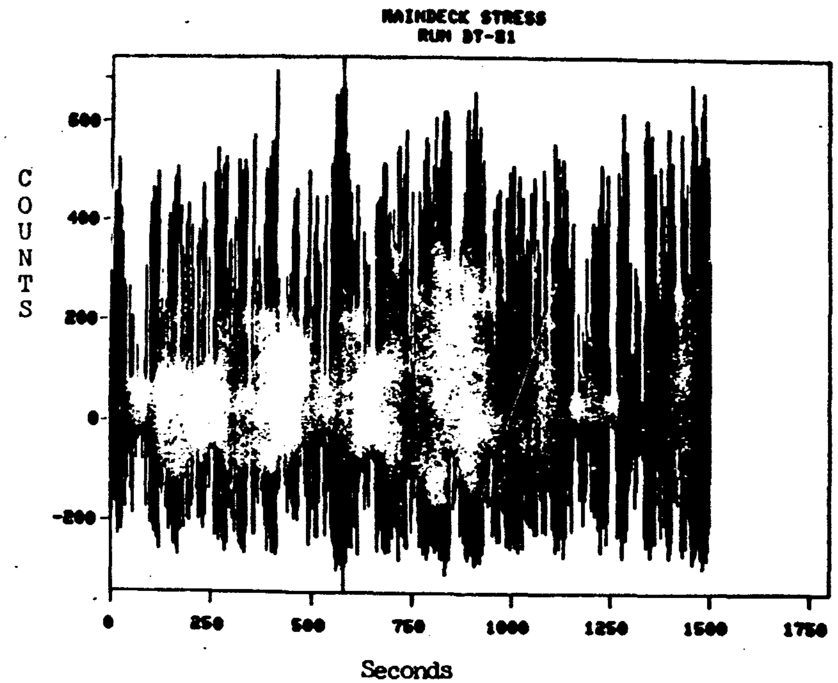

BOTTOM STRESS
RUN BT-77
COUNTS
100
50
0
-50
-100
-150
0
250
500
750
1000
1250
1500
1750
Seconds

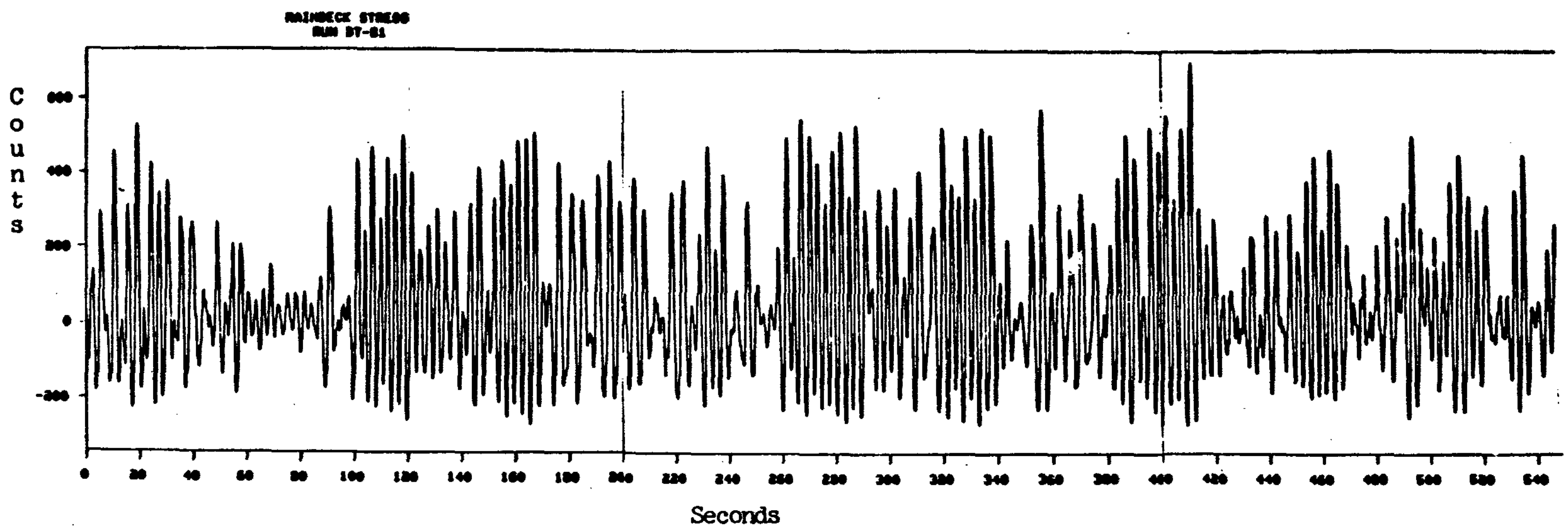

BOTTOM STRESS
RUN BT-77
Counts
100
50
0
-50
-100
-150
Seconds

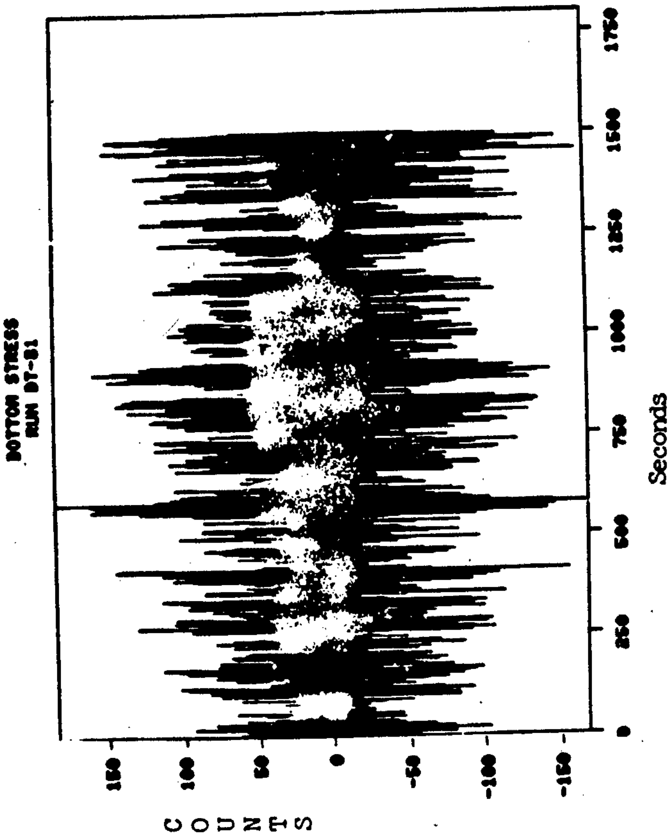
CONDITION 2

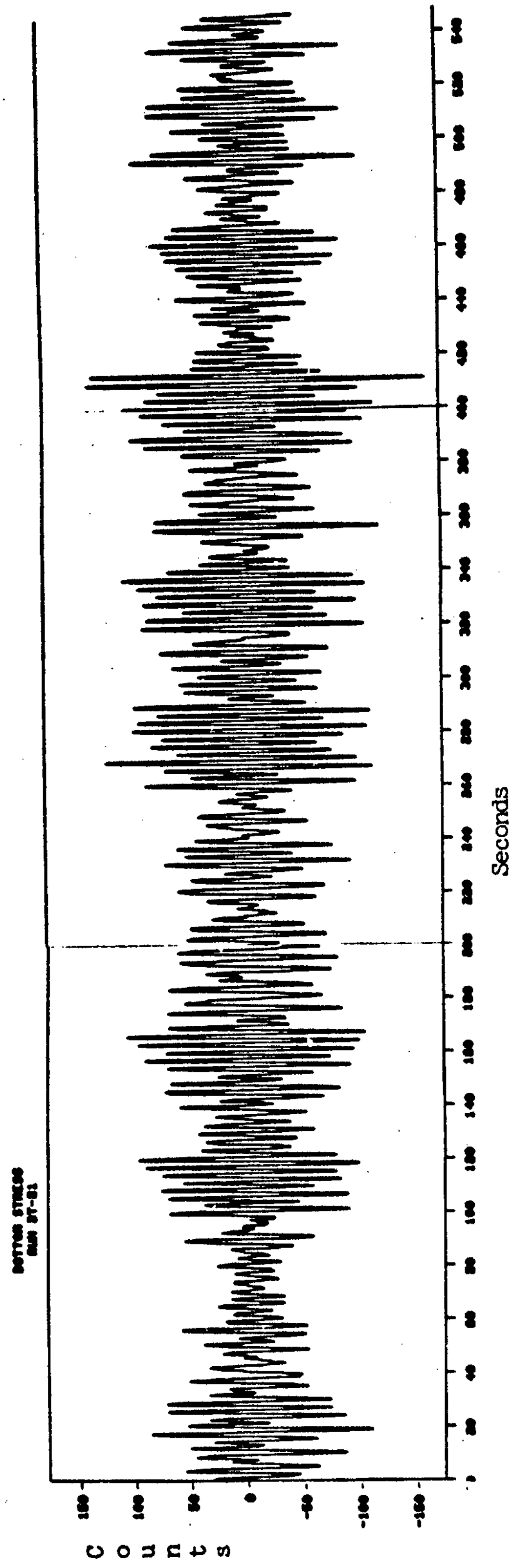
```
M/V S J CORT FALL TRIALS
          RUN           81          POINT            S
          DATE   16-NOV-79          TIME      12:47:34
          DURATION OF RUN IN MINUTES IS          25.000
          NORTH LATITUDE (DD MM)          47 15
          WEST LONGITUDE (DD MM)          90 15
          VESSEL'S SPEED (MPH - XX.X)     14.4
          VESSEL'S HEADING (DEGREES)      254
          VESSEL'S DRAFT (FEET)            20
          WIND DIRECTION (DEGREES)        240
          WIND SPEED (KNOTS)               29
          WAVE DIRECTION (DEGREES)        245
          WAVE HEIGHT (FEET)                6
REMARKS
UPBND SUPERIOR WEST OF KEEWEENAW
LSI CLOCK

End-of-run message
```





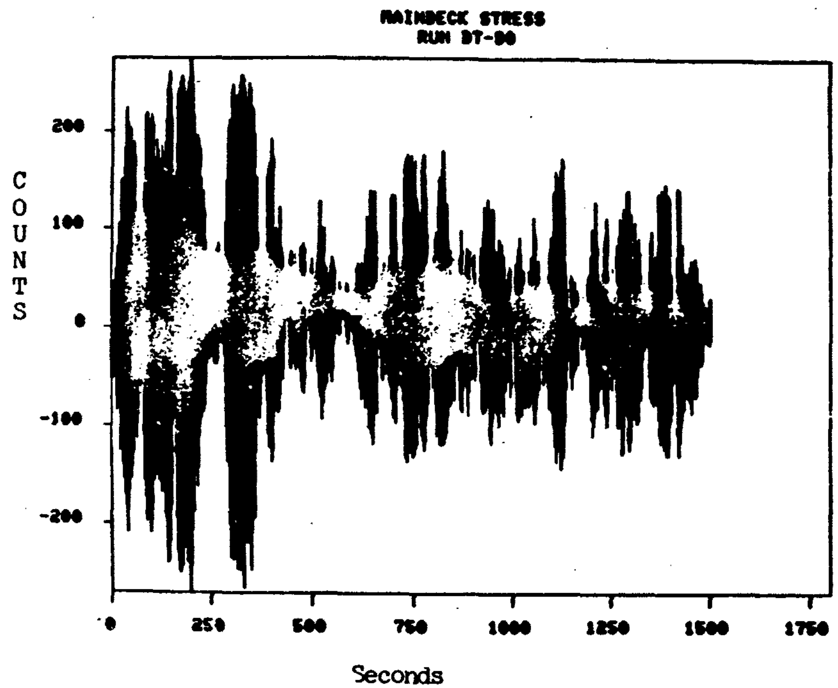

BOTTOM STRESS
RUN BT-81
Seconds
COUNTS
0
250
500
750
1000
1250
1500
1750
150
100
50
0
-50
-100
-150

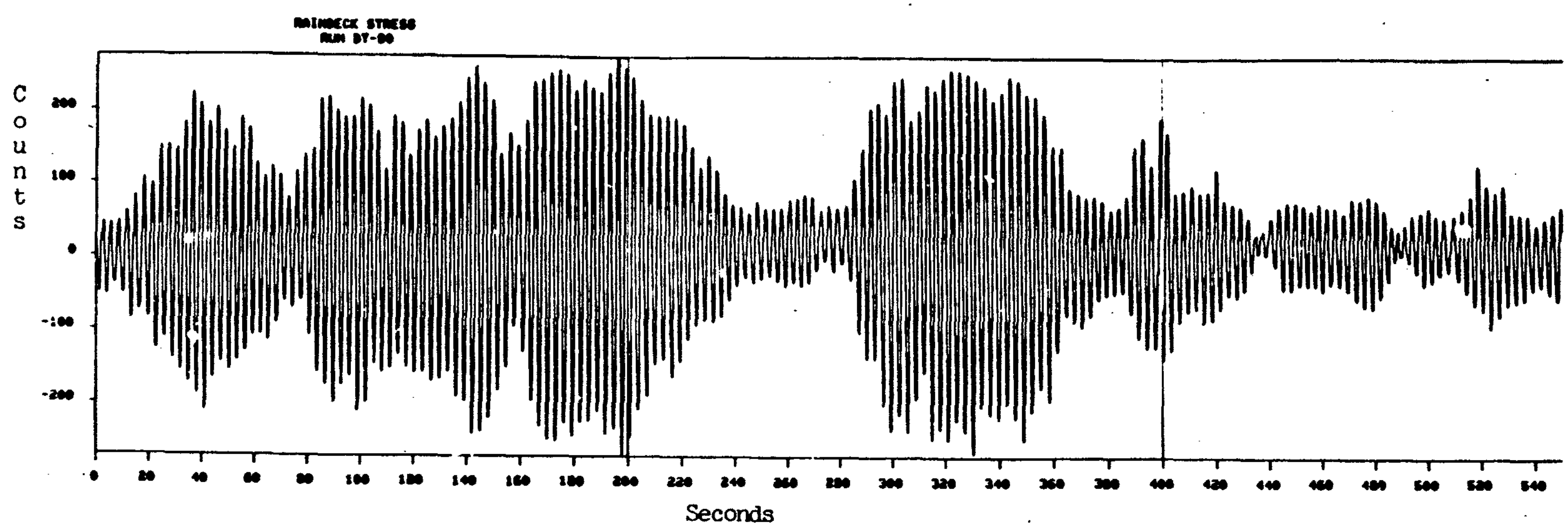

Seconds
Counts
150
100
50
0
-50
-100
-150

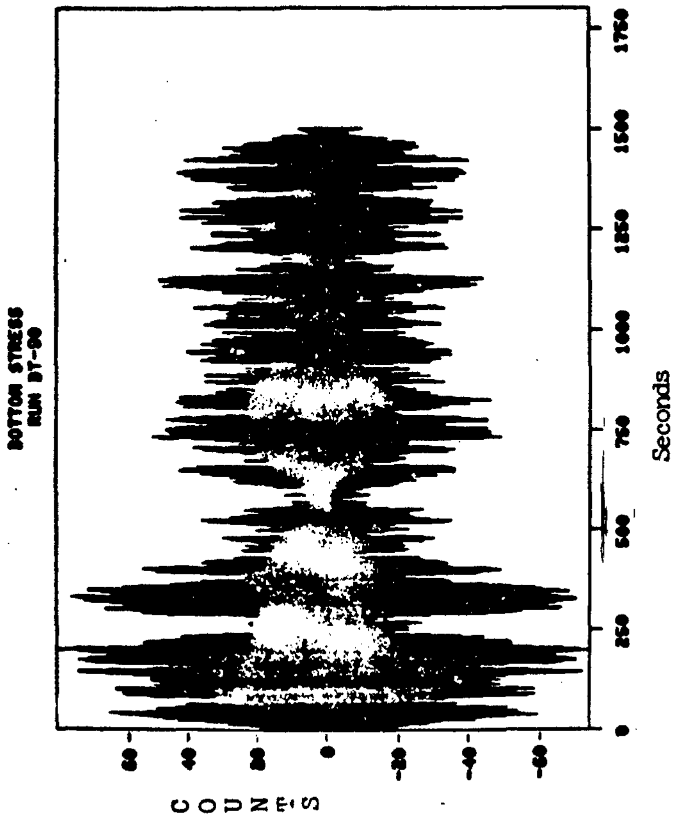
CONDITION 3

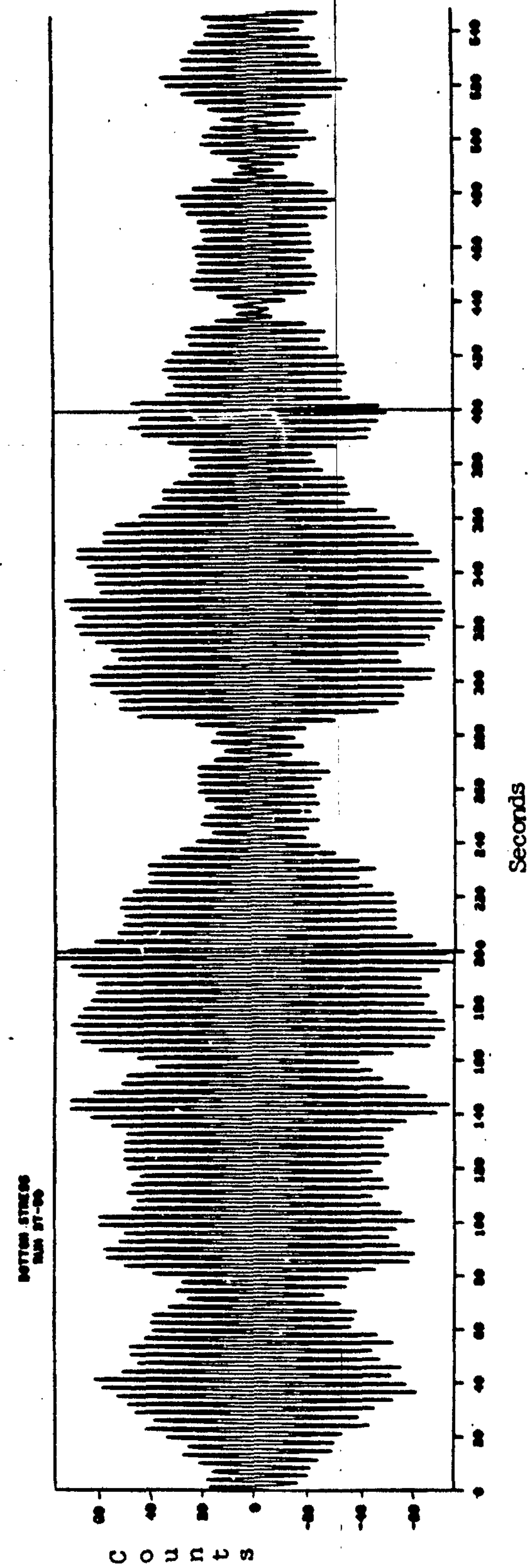
```
M/V S J CORT FALL TRIALS
          RUN            90          POINT          23
          DATE    18-NOV-79          TIME     15:22:45
          DURATION OF RUN IN MINUTES IS            25.000
          NORTH LATITUDE (DD MM)              46 55
          WEST LONGITUDE (DD MM)              85 25
          VESSEL'S SPEED (MPH - XX.X)       14.7
          VESSEL'S HEADING (DEGREES)         114
          VESSEL'S DRAFT (FEET)               27
          WIND DIRECTION (DEGREES)           138
          WIND SPEED (KNOTS)                  16
          WAVE DIRECTION (DEGREES)           120
          WAVE HEIGHT (FEET)                   3
REMARKS
SUPERIOR UPBND, NORTH OF CRISP POINT, HEAD SEA
LSI CLOCK

End-of-run message
```






BOTTOM STRESS
Seconds
COUNTS
0
250
500
750
1000
1250
1500
1750
60
40
20
0
-20
-40
-60

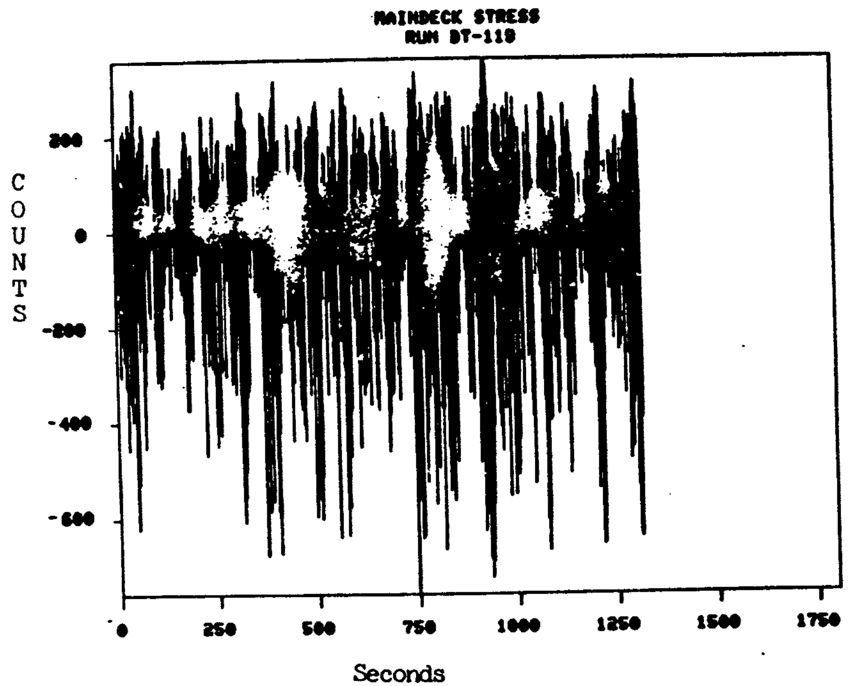

BOTTOM STRESS
Seconds
Counts

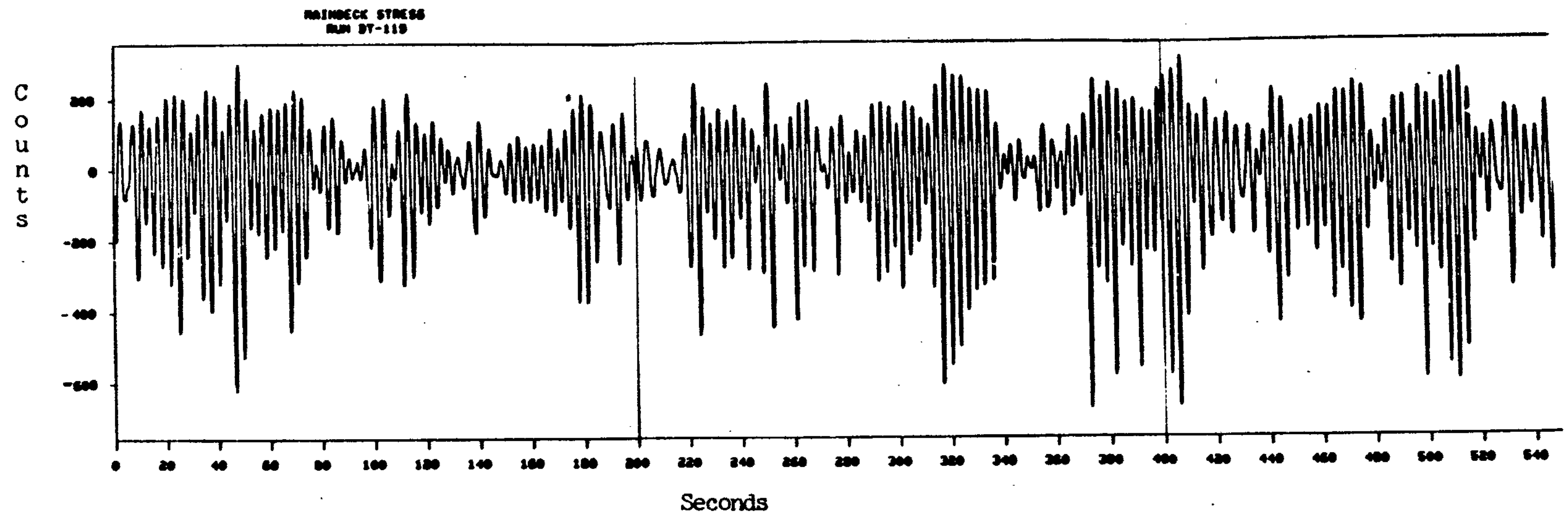
CONDITION 4

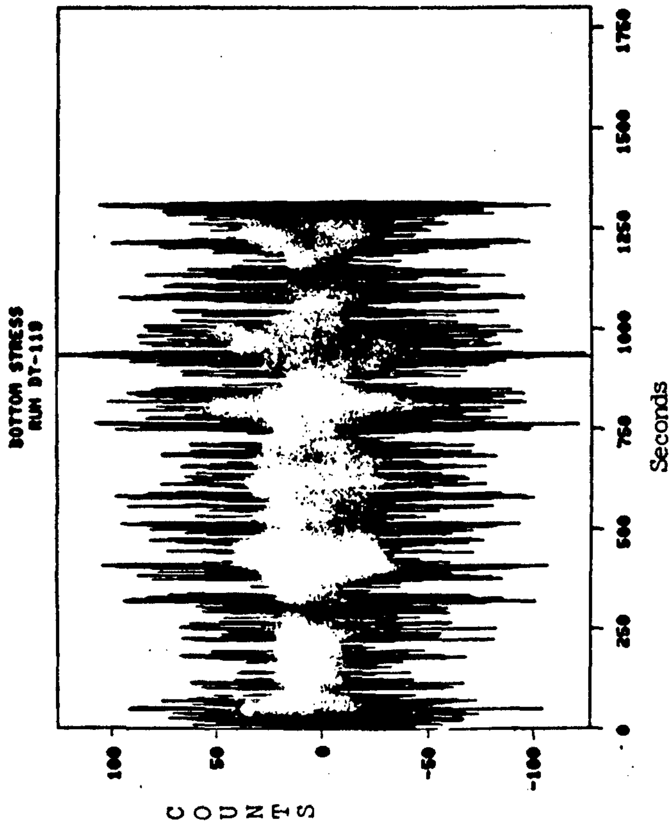
M/V S J CORT FALL TRIALS

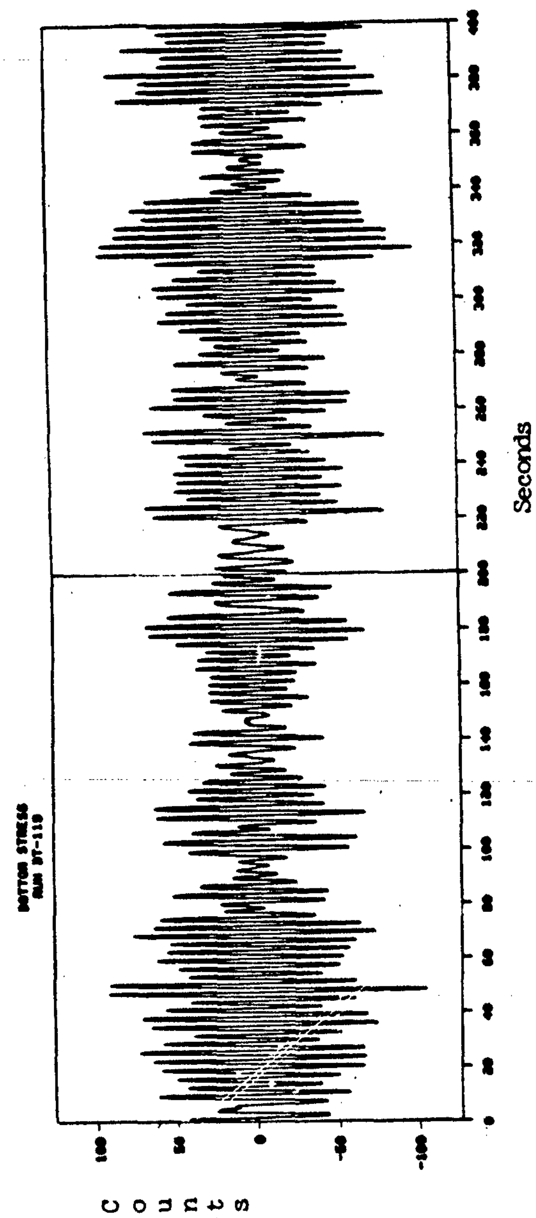
RUN	119	POINT	21
DATE	09-DEC-79	TIME	15:50:07
DURATION OF RUN IN MINUTES IS			25.000
NORTH LATITUDE (DD MM)	86 52		
WEST LONGITUDE (DD MM)	43 9		
VESSEL'S SPEED (MPH - XX.X)	14.2		
VESSEL'S HEADING (DEGREES)	189		
VESSEL'S DRAFT (FEET)	27		
WIND DIRECTION (DEGREES)	209		
WIND SPEED (KNOTS)	10		
WAVE DIRECTION (DEGREES)	198		
WAVE HEIGHT (FEET)	3		

REMARKS
MICHIGAN DNBND, HEAD SEA
2-3 FT SWELL





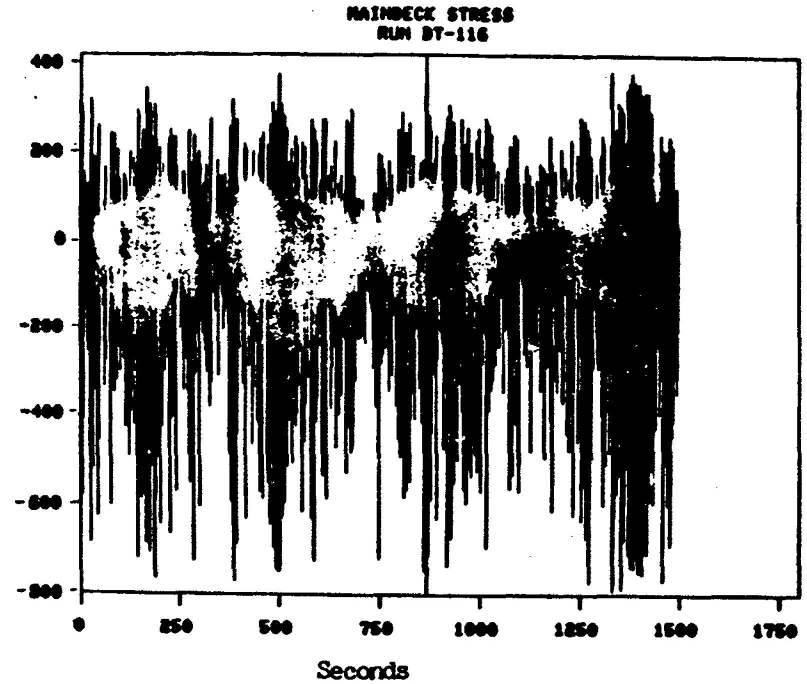

BOTTOM STRESS
Seconds
COUNTS

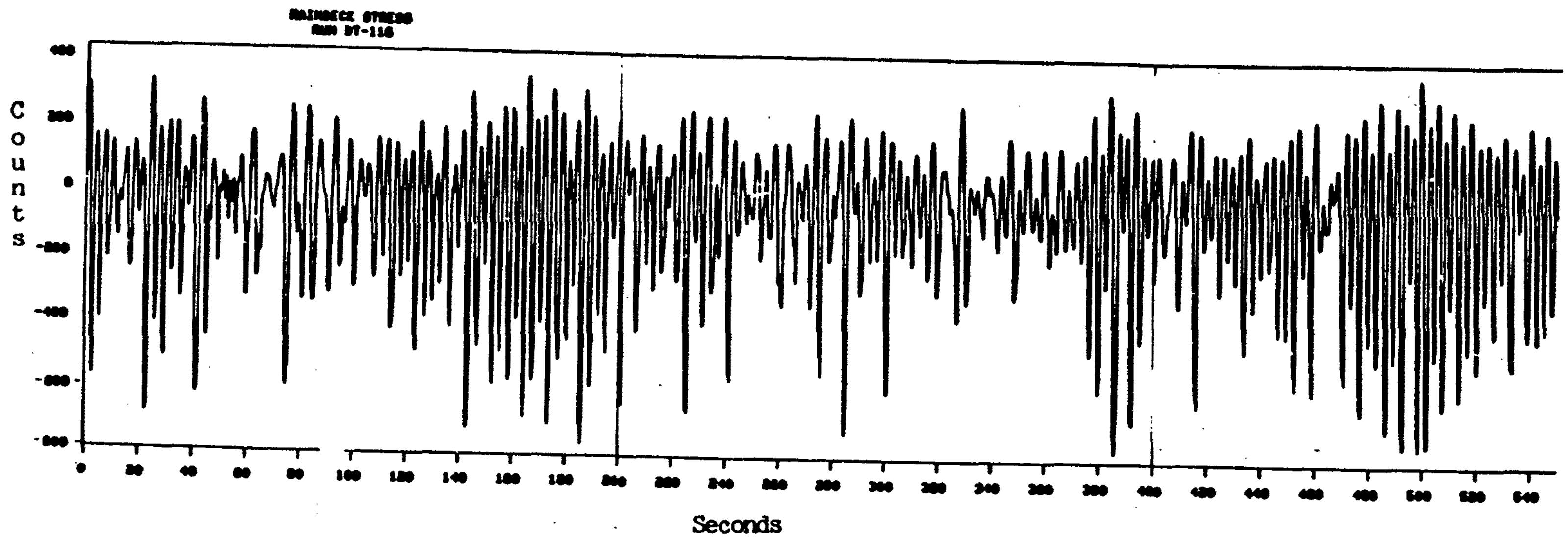

BOTTOM STRESS
Seconds
Counts

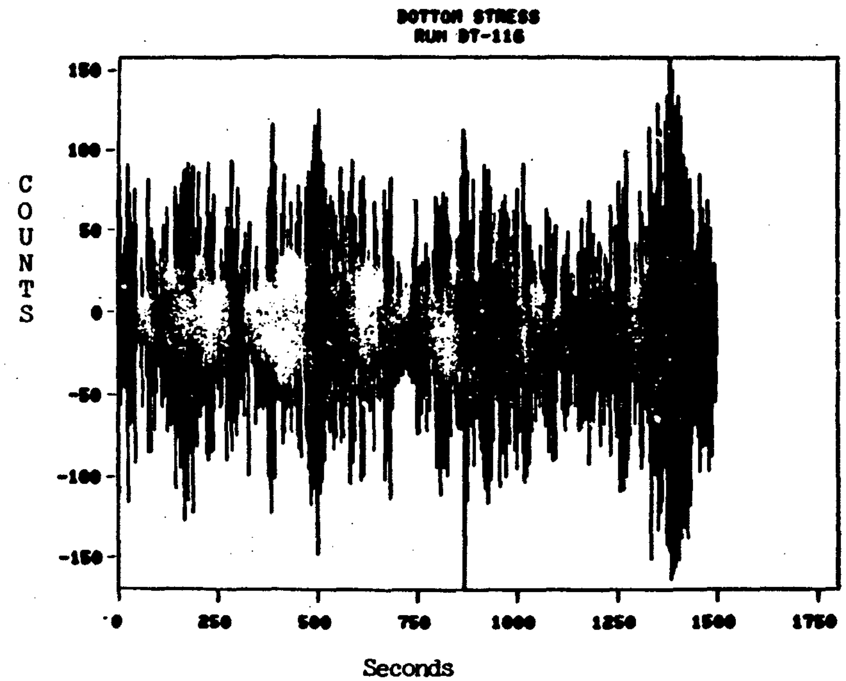
CONDITION 5

```
M/V B J CORT FALL TRIALS
          RUN          116          POINT          15
          DATE   09-DEC-79          TIME     13:42:01
          DURATION OF RUN IN MINUTES IS         25.000
          NORTH LATITUDE (DD MM)             87  7
          WEST LONGITUDE (DD MM)             44  8
          VESSEL'S SPEED (MPH - XX.X)      13.5
          VESSEL'S HEADING (DEGREES)        109
          VESSEL'S DRAFT (FEET)              27
          WIND DIRECTION (DEGREES)          247
          WIND SPEED (KNOTS)                 18
          WAVE DIRECTION (DEGREES)          212
          WAVE HEIGHT (FEET)                  4
REMARKS
MICHIGAN INBND, HEAD/BOW SEA, HEAD PRED
SEA DYING

End-of-run message
```






BOTTOM STRESS
RUN BT-116
COUNTS
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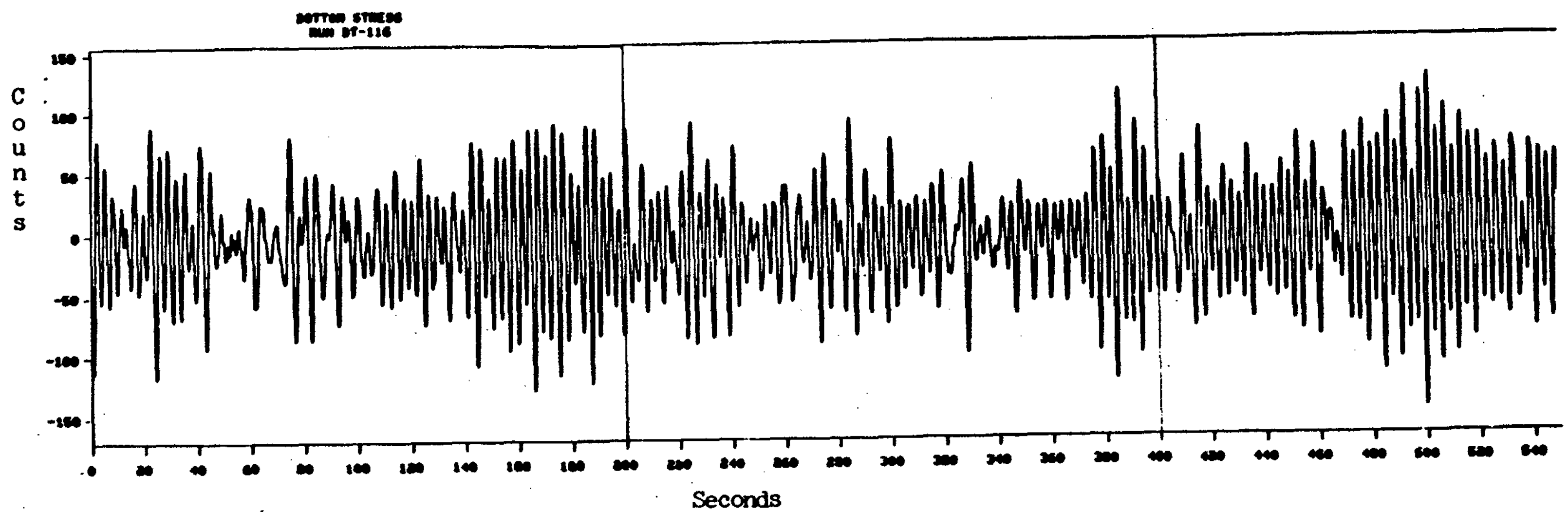
100
50
0
-50
-100
-150
0
250
500
750
1000
1250
1500
1750
Seconds


BOTTOM STRESS
RUN BT-116
Counts
Seconds

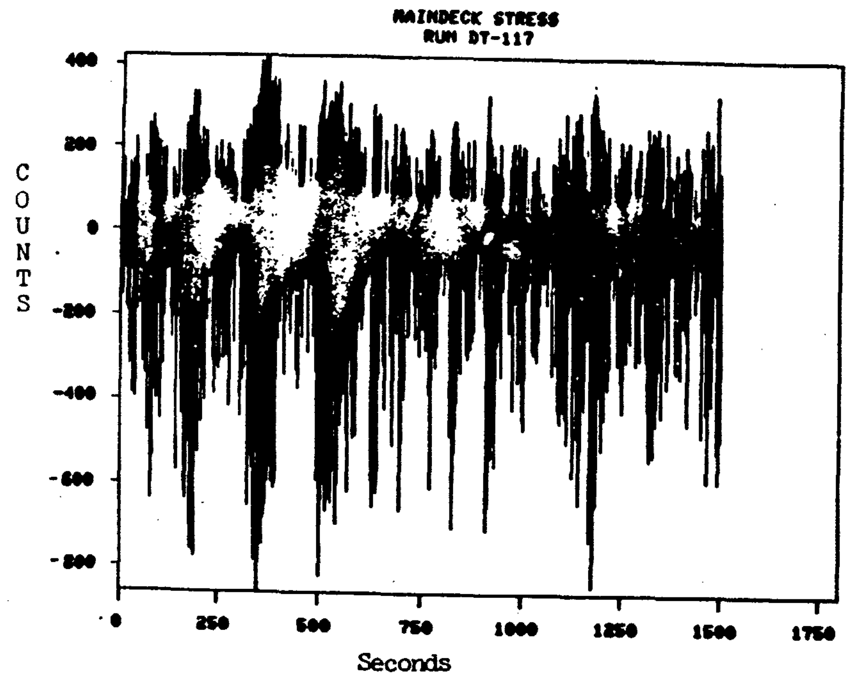
CONDITION 6

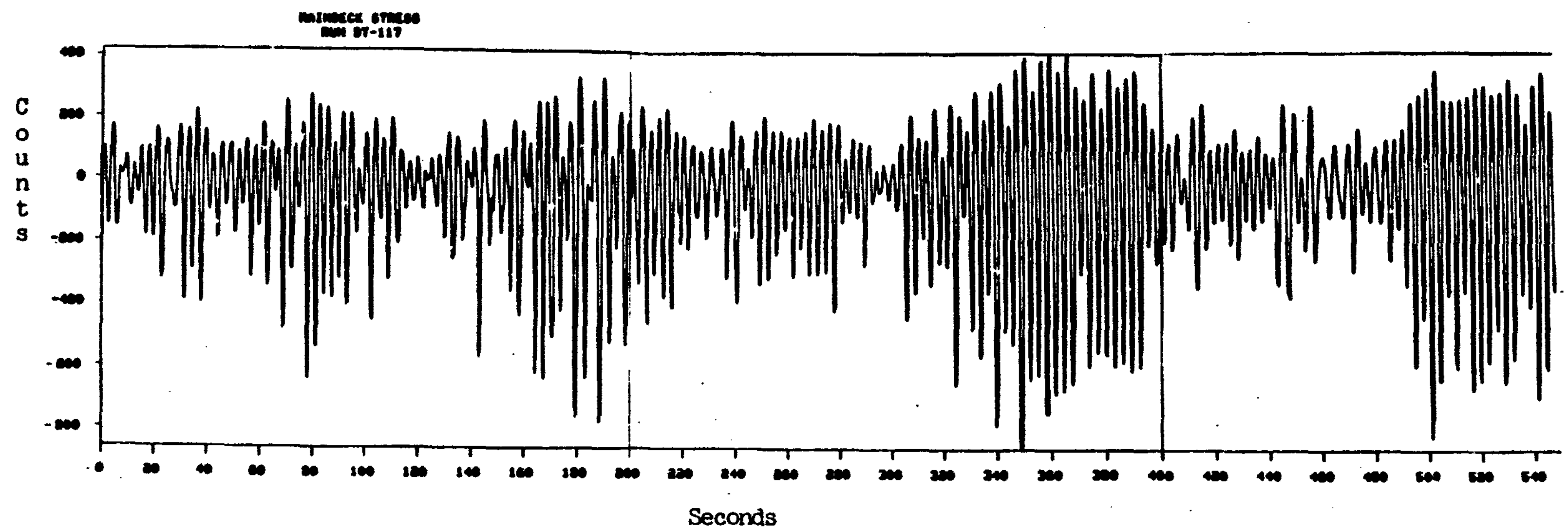
M/V B J CORT FALL TRIALS

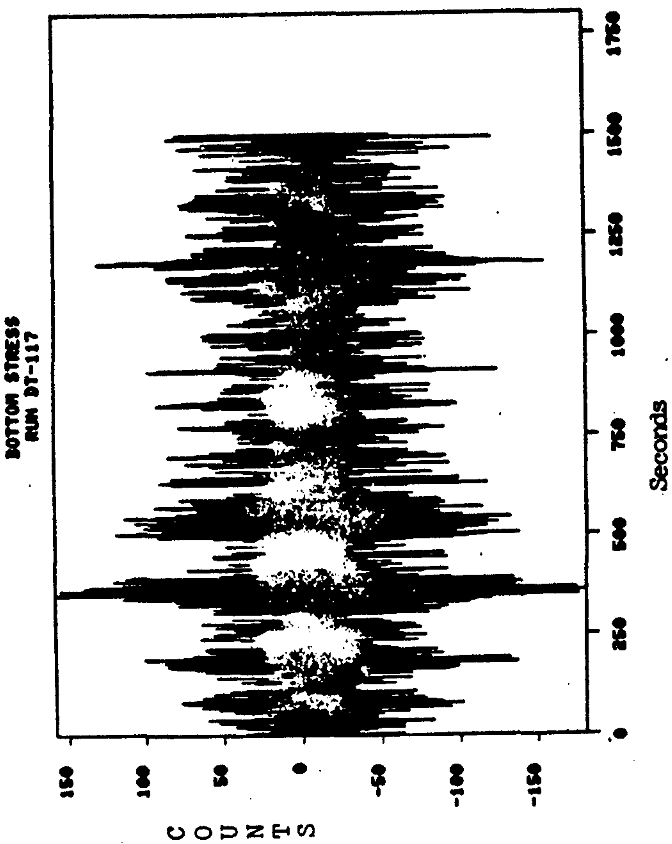
RUN	117	POINT	17
DATE	09-DEC-79	TIME	15104156
DURATION OF RUN IN MINUTES IS			25.000
NORTH LATITUDE (DD MM)			87 13
WEST LONGITUDE (DD MM)			43 20
VESSEL'S SPEED (MPH - XX.X)			13.5
VESSEL'S HEADING (DEGREES)			188
VESSEL'S DRAFT (FEET)			27
WIND DIRECTION (DEGREES)			263
WIND SPEED (KNOTS)			14
WAVE DIRECTION (DEGREES)			198
WAVE HEIGHT (FEET)			3

REMARKS
MICHIGAN DNBND, HEAD SEA
2-3 FT SWELL

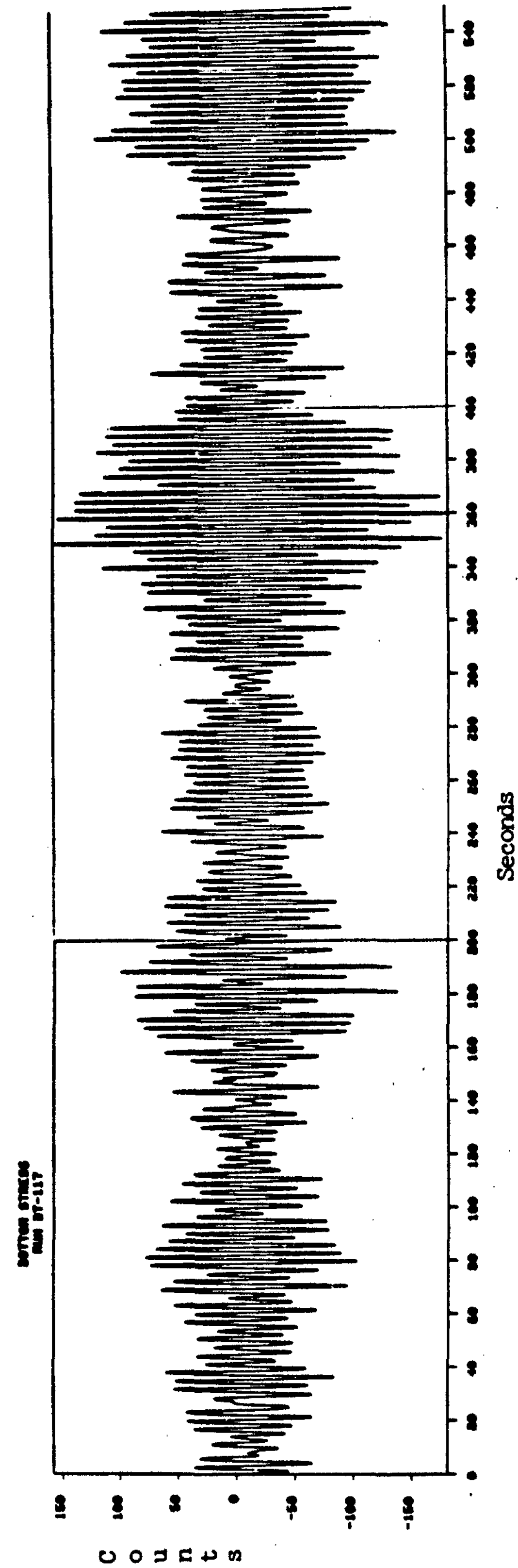
End-of-run message







BOTTOM STRESS
RUN BT-117
Seconds
COUNTS

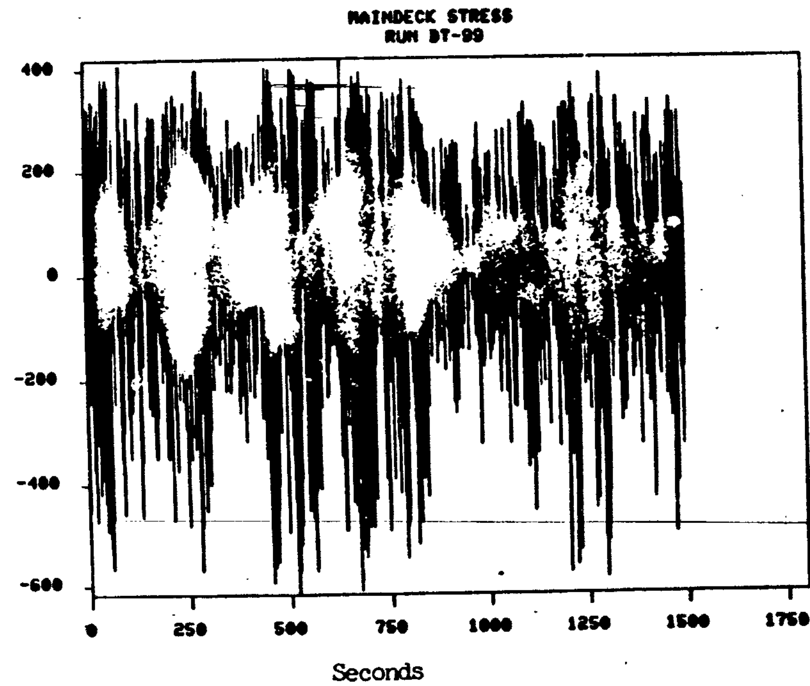


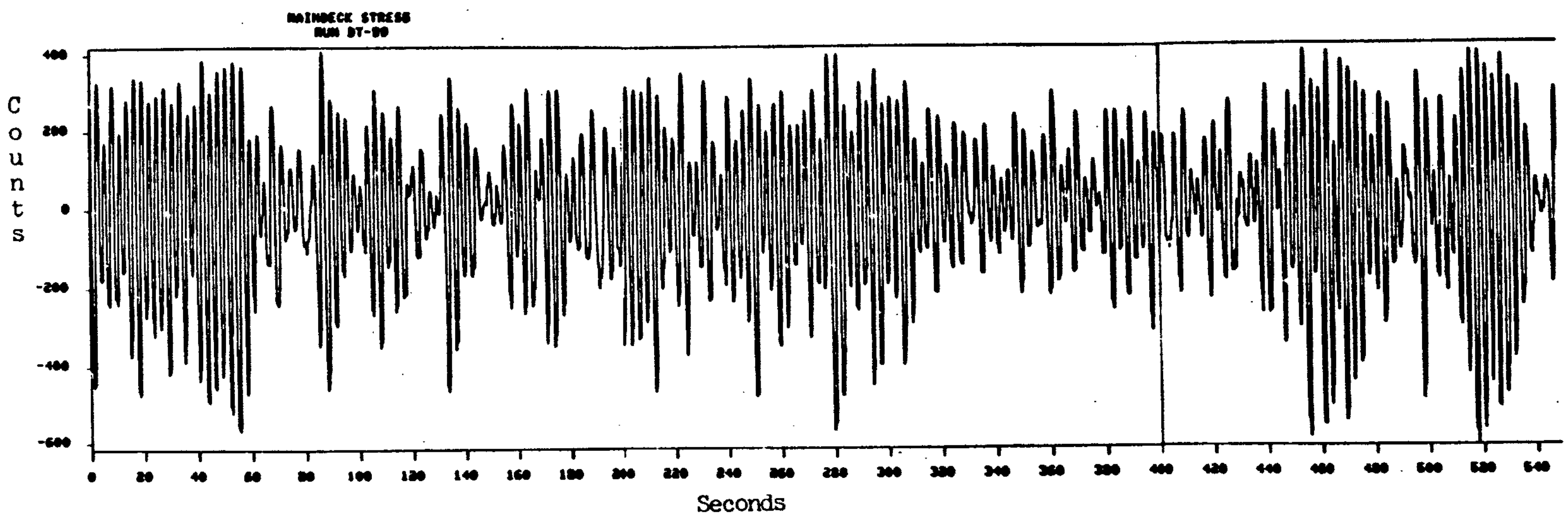
BOTTOM STRESS
RUN BT-117
Seconds
Counts

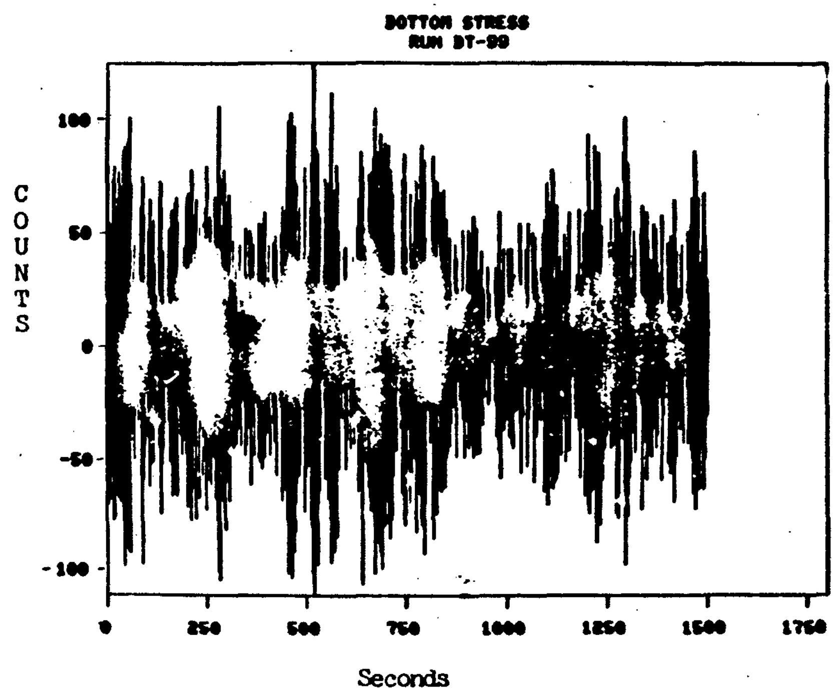
CONDITION 7

```
M/V B J CORT FALL TRIALS
        RUN            99          POINT          14
        DATE   05-DEC-79           TIME     14111119
        DURATION OF RUN IN MINUTES IS         25.000
        NORTH LATITUDE (DD MM)            88  0
        WEST LONGITUDE (DD MM)            47 35
        VESSEL'S SPEED (MPH - XX.X)      11.6
        VESSEL'S HEADING (DEGREES)        270
        VESSEL'S DRAFT (FEET)              18
        WIND DIRECTION (DEGREES)          270
        WIND SPEED (KNOTS)                 15
        WAVE DIRECTION (DEGREES)          270
        WAVE HEIGHT (FEET)                  5
REMARKS
SUPERIOR, UPBND., HEAD SEA, CODE 3
7 MI. OFF KEWEENAW PENINSULA , PT. OUTBD. ENGINE CLEARED

End-of-run message
```






BOTTOM STRESS
RUN BT-99
COUNTS
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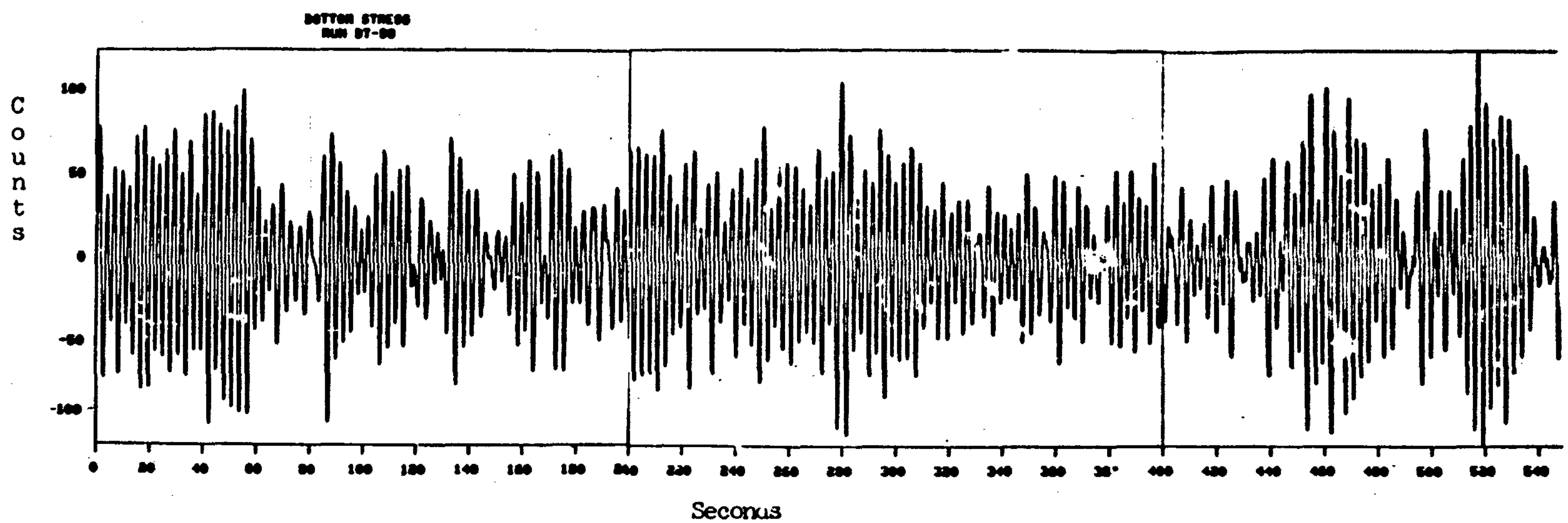
50
0
-50
-100
0
250
500
750
1000
1250
1500
1750
Seconds


BOTTOM STRESS
RUN BT-99
Counts
100
50
0
-50
-100
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
Seconds

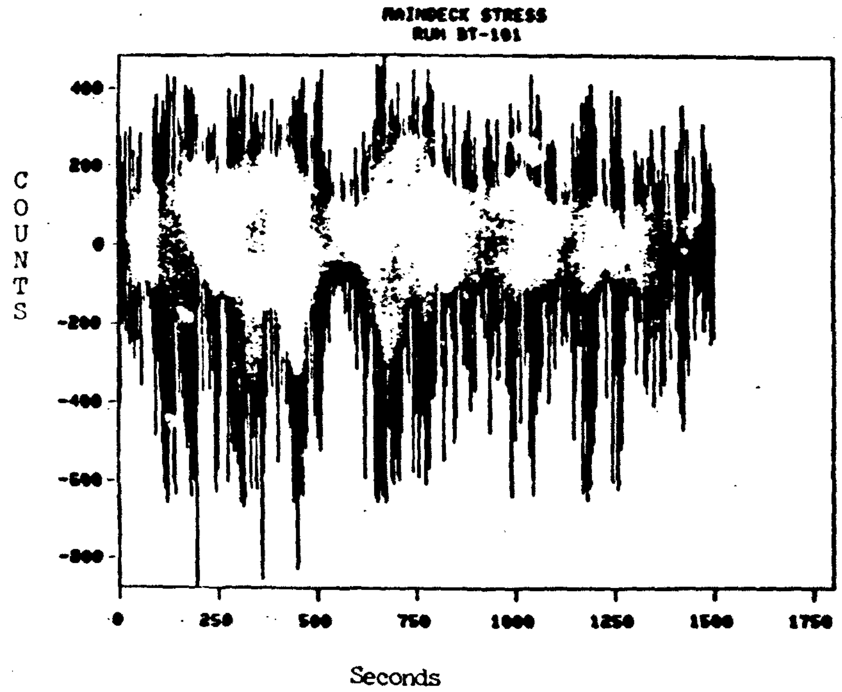
CONDITION 8

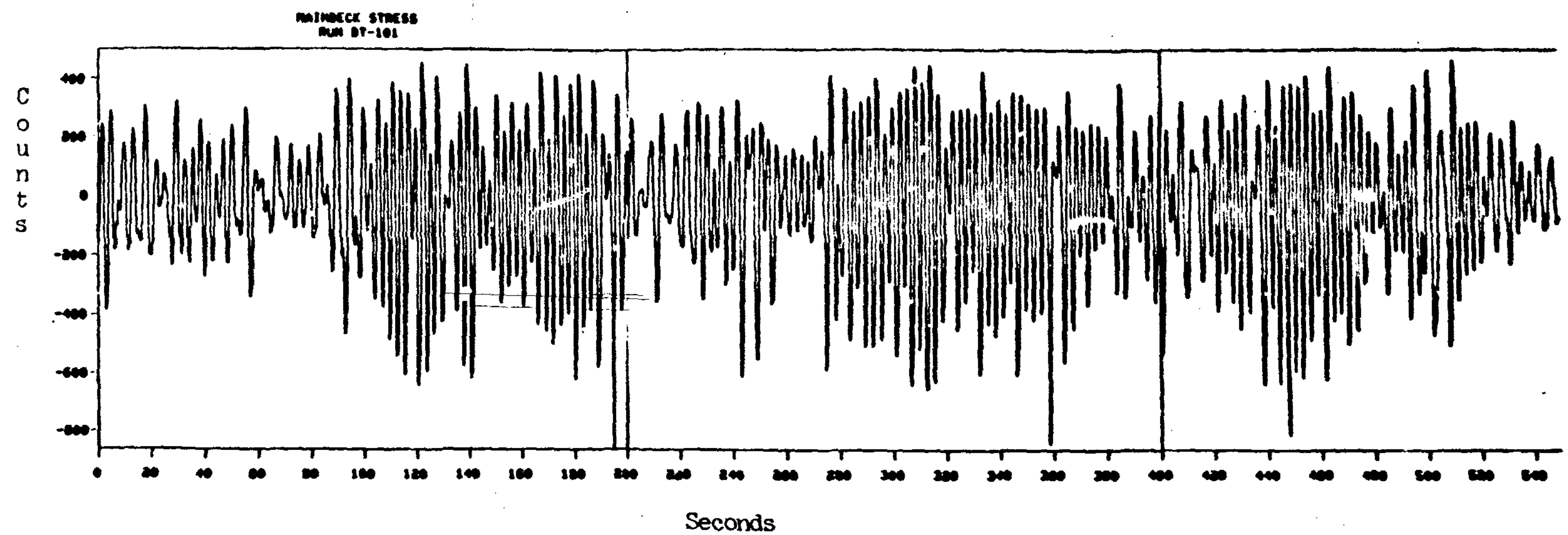
M/V B J CORT FALL TRIALS

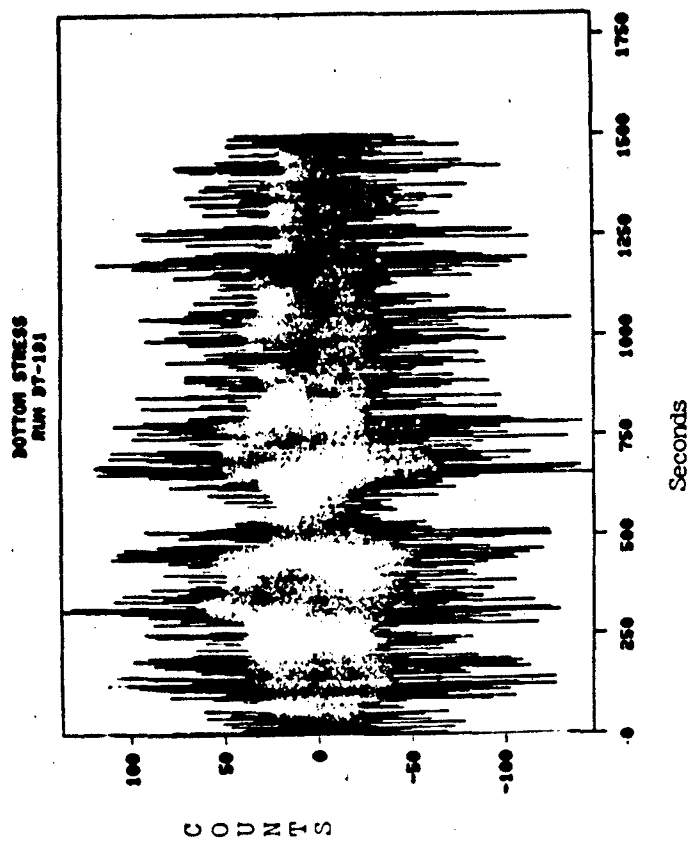
RUN	101	POINT	18
DATE	05-DEC-79	TIME	14:53:38
DURATION OF RUN IN MINUTES IS			25.000
NORTH LATITUDE (DD MM)		88 20	
WEST LONGITUDE (DD MM)		47 30	
VESSEL'S SPEED (MPH - XX.X)		11.6	
VESSEL'S HEADING (DEGREES)		260	
VESSEL'S DRAFT (FEET)		19	
WIND DIRECTION (DEGREES)		350	
WIND SPEED (KNOTS)		27	
WAVE DIRECTION (DEGREES)		240	
WAVE HEIGHT (FEET)		5	

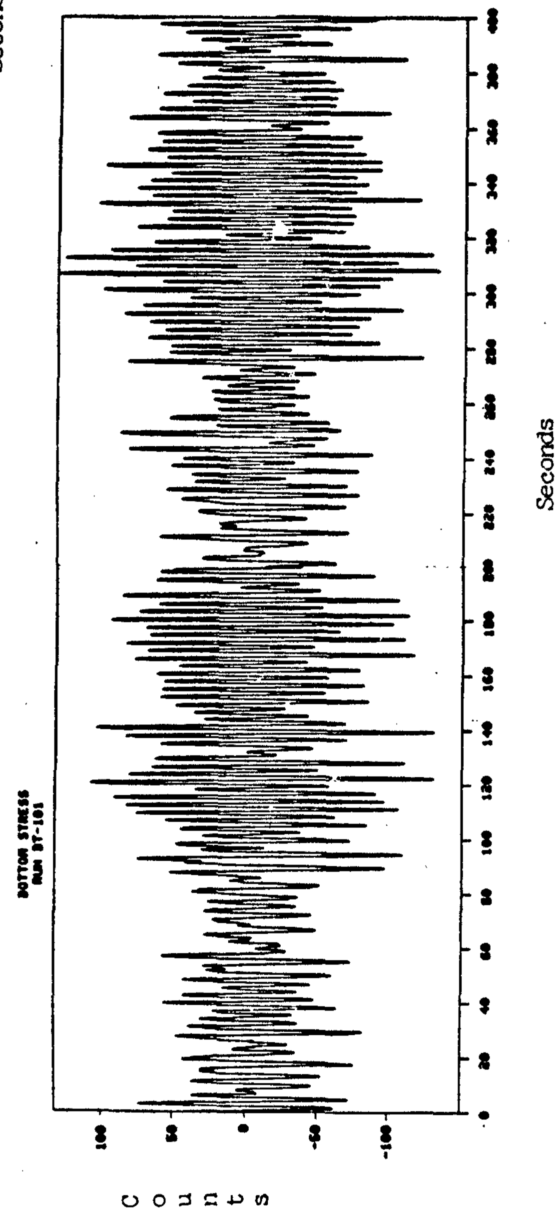
REMARKS
SUPERIOR, UPBND., PORT BOW SEA CODE 3
OFF KEWEENAW PENINSULA

End-of-run message
PREDOMINANT SEA FROM PT BOW BEING KNOCKED DN BY STBD GALE
BECOMING CONFUSED






BOTTOM STRESS
COUNTS
100
50
0
-50
-100
0
250
500
750
1000
1250
1500
1750
Seconds


BOTTOM STRESS
COUNTS
100
50
0
-50
-100
Seconds

APPENDIX E

American Bureau of Shipping

ABS has submitted updated versions of the vertical bending moment transfer functions for the M/V STEWART J. CORT. These versions are shown in Parts A, B, and C of this Appendix. Part C is the most recent version and was extracted from:

American Bureau of Shipping
Ocean Engineering Division
Technical Report OE-81001
"Evaluation of Analysis Methods for Predicting Hull Girder Dynamic Responses in Waves"
January 1981
Y. N. Chen
J. W. Chion

Part A

Transfer Functions of Vertical Bending Moments
Amidships for M/V STEWART J. CORT

30 May 1980

American Bureau of Shipping
Sixty-five Broadway
New York, N.Y. 10006

Refer to: DL/ml
File Ref.: RD-1

30 May 1980

Lt. Mark Noll
U.S. Coast Guard Headquarters (G-DMT-1/TP54)
2100 2nd Street, S.W.
Washington, D.C. 20593

Subject: Transfer Functions of Vertical Bending Moment Amidships for M/V STEWART J. CORT

Dear Lt. Noll:

Enclosed please find our theoretical results of the subject analysis, which are presented in both tabular and graphic forms. The analysis was performed for the eight conditions specified by Capt. Veillette's letter of 5 March 1980, addressed to our Dr. H.H. Chen. In our calculation, the load distribution which has to be input to our computer program was obtained by adjusting the loading conditions that were sent to Dr. Chen in a subsequent letter of 14 May 1980. The adjustment was made so that the forward and aft drafts were the same as given in the 5 March 1980 letter. Therefore, the load distribution used in our calculation may be different from the actual case.

Kindly notice that in the tables enclosed herewith, ω_e and ω are the frequency of encounter and the wave frequency, respectively. M_v is the vertical bending moment amidships of the ship in a wave of one foot amplitude. Thus, M_v is the transfer function of vertical bending moment.

We understand that DWTNSRDC will compare the calculated transfer function with the measured data. We would appreciate receiving the final report on the correlation, whenever it becomes available.

TELEPHONE: 212-440-0300 CABLE ADDRESS "RECORD" TWX: 710-581-3089 TELEX: ITT 421966 RCA 232099 WUI 620353

Should you have any questions regarding our calculation, please feel free to contact Dr. Chen at (212) 440-0466.

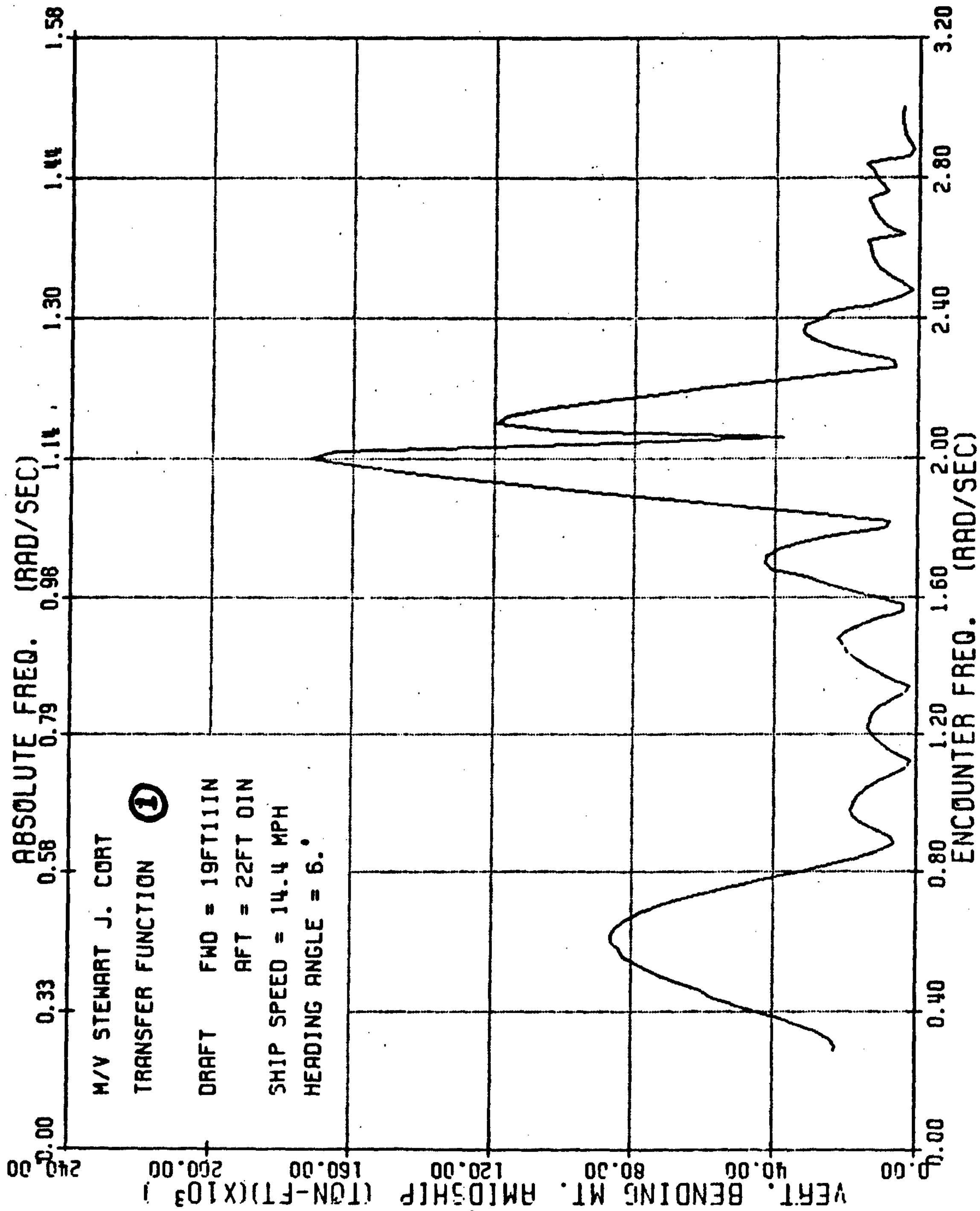
Very truly yours,

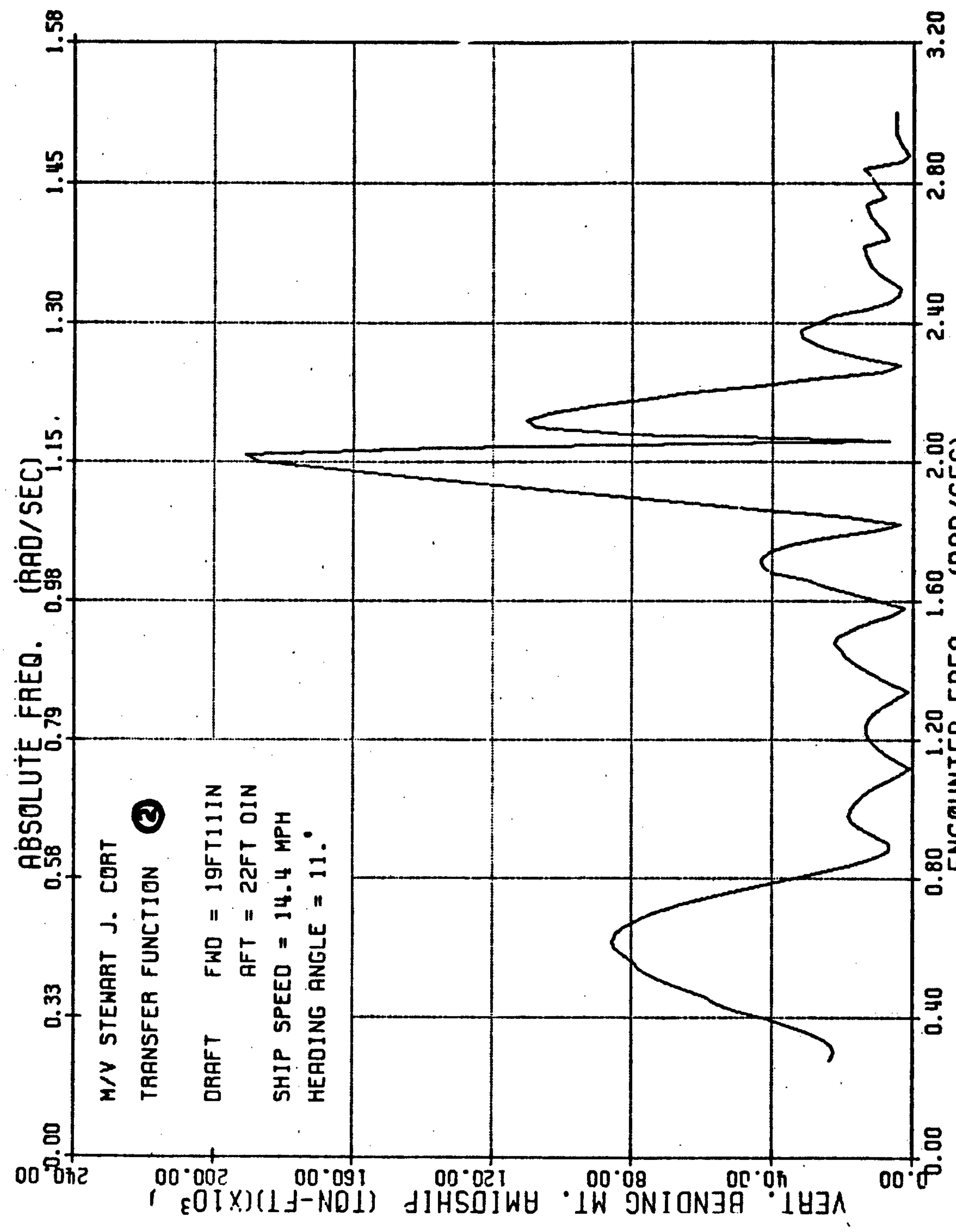
AMERICAN BUREAU OF SHIPPING

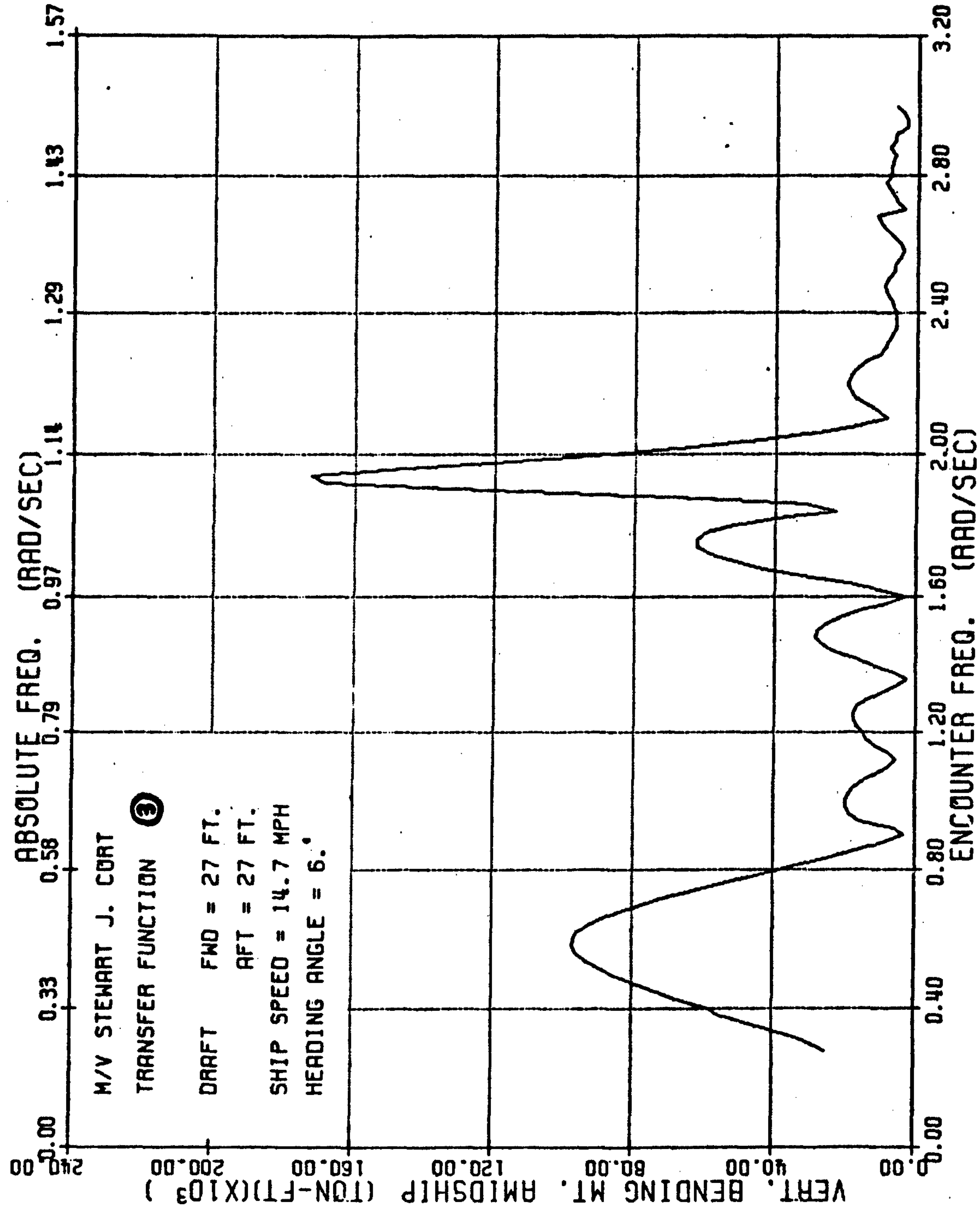
Stanley G. Stiansen
Vice President

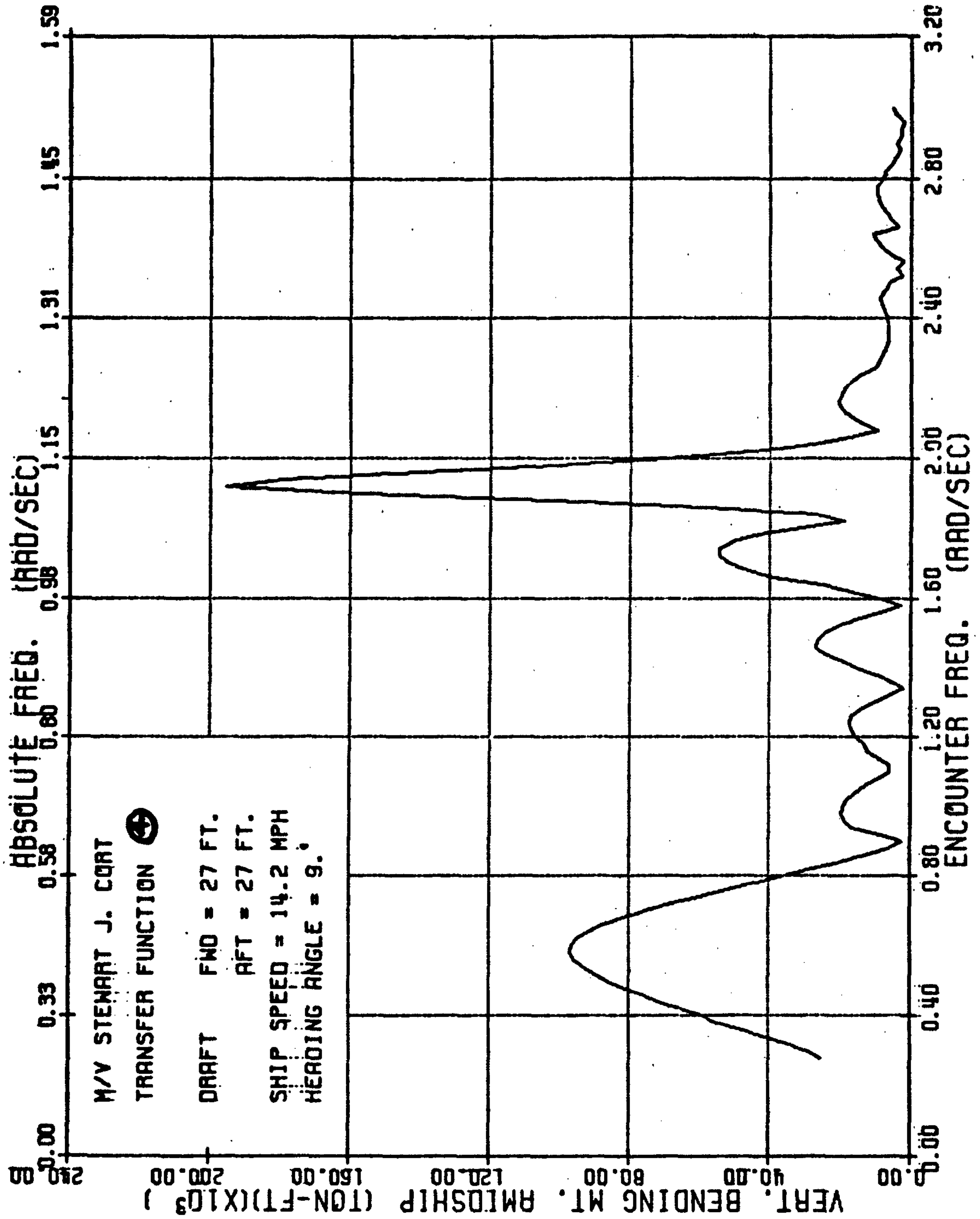
By: Donald Liu
Donald Liu
Chief Research Engineer

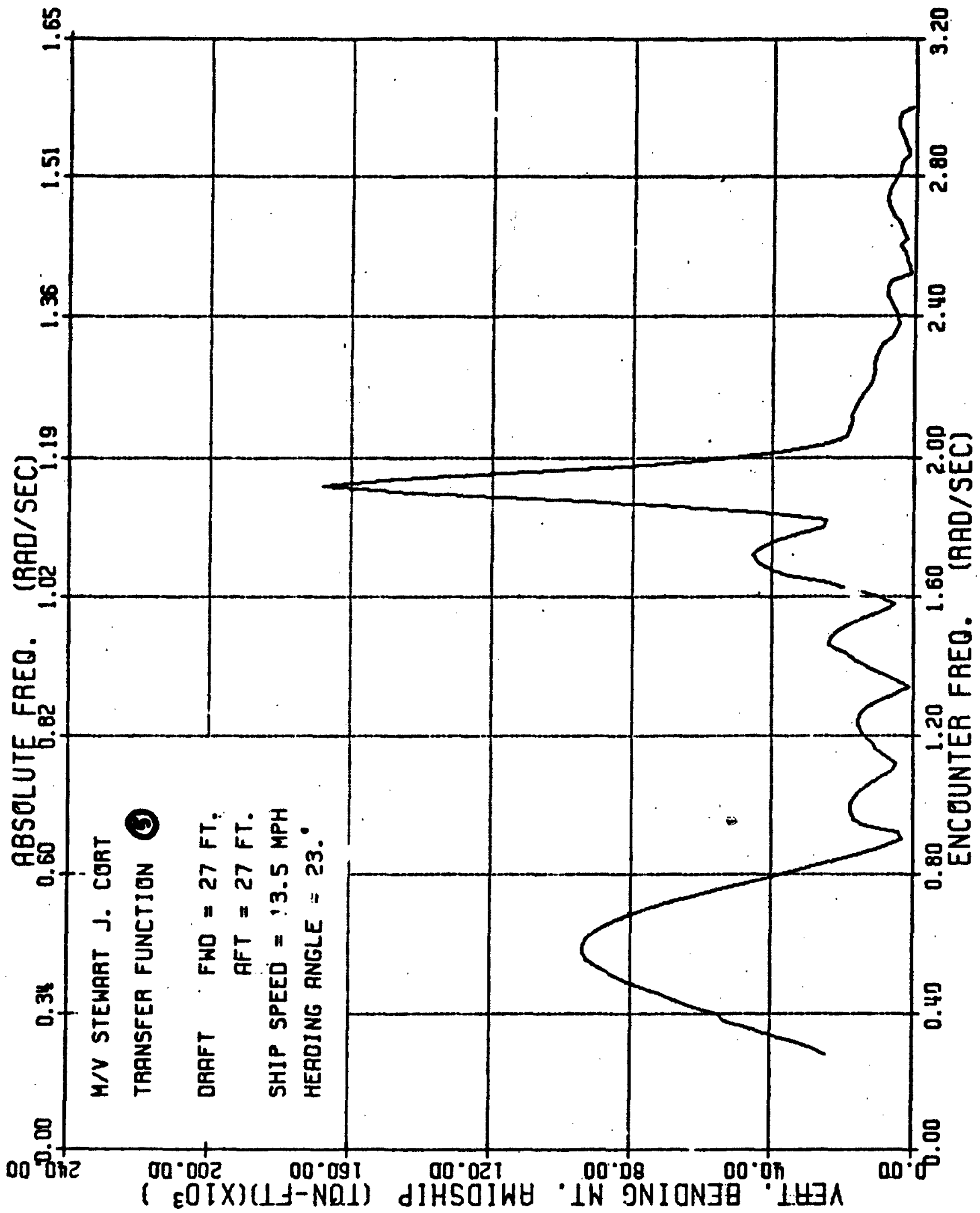
Encl:

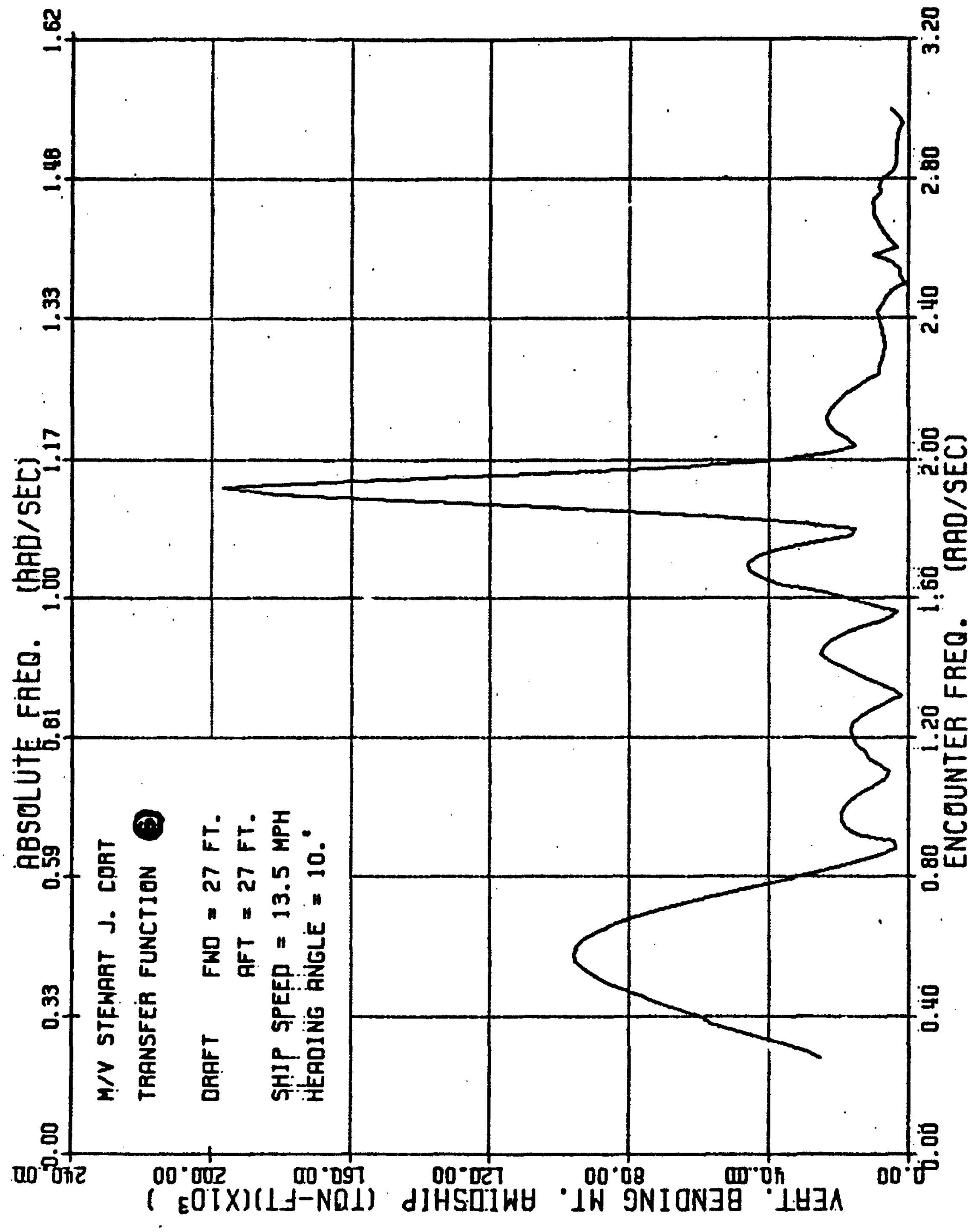

M/V STEWART J. CORT
TRANSFER FUNCTION 1
DRAFT FWD = 19FT11IN
AFT = 22FT 0IN
SHIP SPEED = 14.4 MPH
HEADING ANGLE = 6.°
ABSOLUTE FREQ. (RAD/SEC)
0.00 0.33 0.58 0.79 0.98 1.14 1.30 1.44 1.58
ENCOUNTER FREQ. (RAD/SEC)
0.00 0.40 0.80 1.20 1.60 2.00 2.40 2.80 3.20
VERT. BENDING MT. AMIDSHIP (TON-FT)(X10³)
0.00 40.00 80.00 120.00 160.00 200.00 240.00


M/V STEWART J. CORT
TRANSFER FUNCTION 2
DRAFT FWD = 19FT11IN
AFT = 22FT 0IN
SHIP SPEED = 14.4 MPH
HEADING ANGLE = 11.°
ABSOLUTE FREQ. (RAD/SEC)
0.00
0.33
0.58
0.79
0.98
1.15
1.30
1.45
1.58
ENCOUNTER FREQ. (RAD/SEC)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
VERT. BENDING MT. AMIDSHIP (TON-FT)(X10³)
0.00
40.00
80.00
120.00
160.00
200.00
240.00

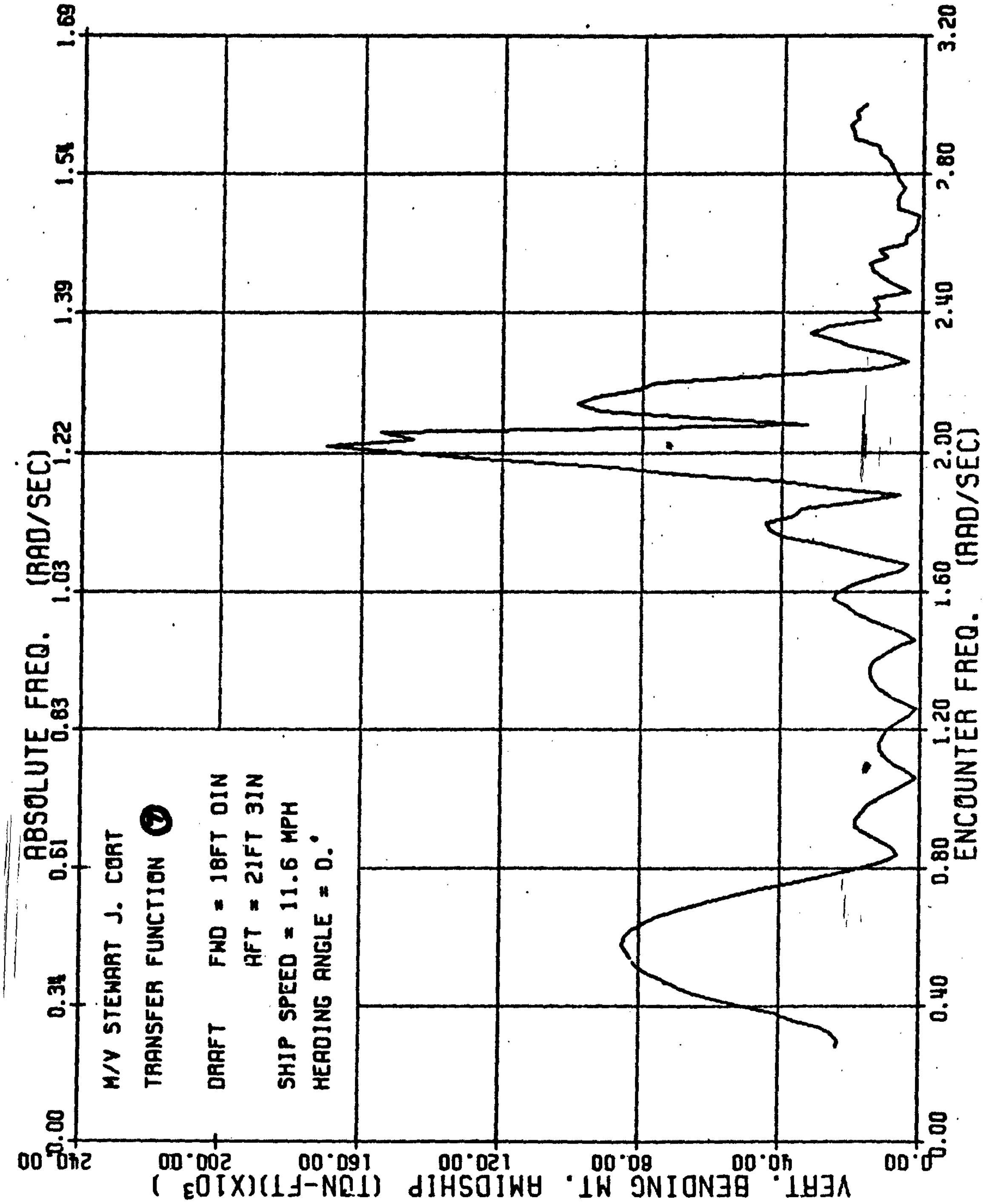

M/V STEWART J. CORT
TRANSFER FUNCTION 3
DRAFT FWD = 27 FT.
AFT = 27 FT.
SHIP SPEED = 14.7 MPH
HEADING ANGLE = 6.°
ABSOLUTE FREQ. (RAD/SEC)
ENCOUNTER FREQ. (RAD/SEC)
VERT. BENDING MT. AMIDSHIP (TON-FT)(X10³)


M/V STEWART J. CORT
TRANSFER FUNCTION
DRAFT FWD = 27 FT.
AFT = 27 FT.
SHIP SPEED = 14.2 MPH
HEADING ANGLE = 9.
ABSOLUTE FREQ. (RAD/SEC)
0.00
0.33
0.58
0.80
0.98
1.15
1.31
1.45
1.59
ENCOUNTER FREQ. (RAD/SEC)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
VERT. BENDING MT. AMIDSHIP (TON-FT)(X10³)
0.00
40.00
80.00
120.00
160.00
200.00
240.00

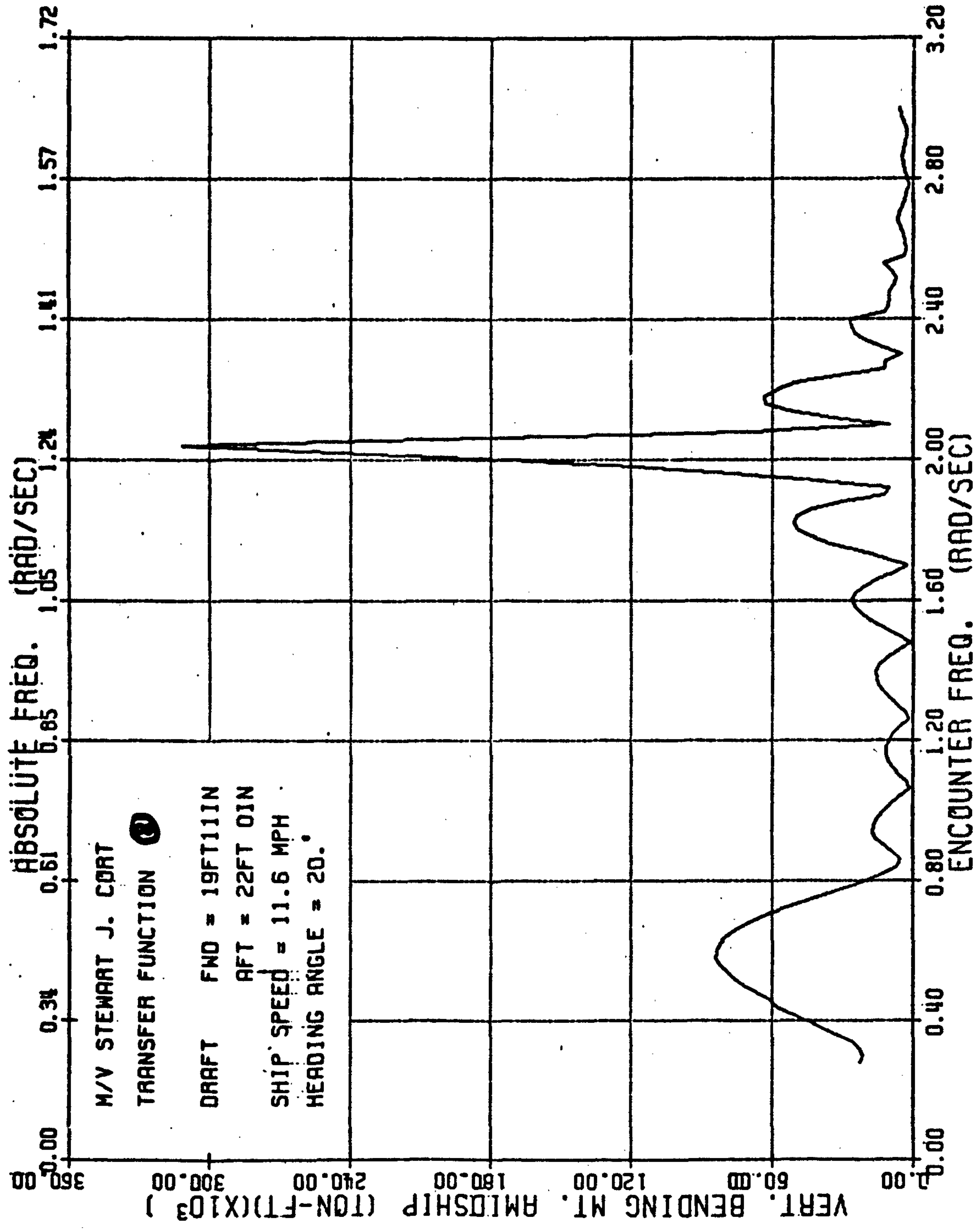

M/V STEWART J. CORT
TRANSFER FUNCTION 5
DRAFT FWD = 27 FT.
AFT = 27 FT.
SHIP SPEED = 13.5 MPH
HEADING ANGLE = 23.°
ABSOLUTE FREQ. (RAD/SEC)
0.00
0.3%
0.60
0.82
1.02
1.19
1.36
1.51
1.65
ENCOUNTER FREQ. (RAD/SEC)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
VERT. BENDING MT. AMIDSHIP (TON-FT)(X10³)
0.00
40.00
80.00
120.00
160.00
200.00
240.00



M/V STEWART J. CORT
TRANSFER FUNCTION 6
DRAFT FWD = 27 FT.
AFT = 27 FT.
SHIP SPEED = 13.5 MPH
HEADING ANGLE = 10.°
ABSOLUTE FREQ. (RAD/SEC)
0.00
0.33
0.59
0.81
1.00
1.17
1.33
1.48
1.62
ENCOUNTER FREQ. (RAD/SEC)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
VERT. BENDING MT. AMIDSHIP (TON-FT)(X10³)
0.00
40.00
80.00
120.00
160.00
200.00
240.00



M/V STEWART J. CORT
TRANSFER FUNCTION 7
DRAFT FWD = 18FT 0IN
AFT = 21FT 3IN
SHIP SPEED = 11.6 MPH
HEADING ANGLE = 0.°
ABSOLUTE FREQ. (RAD/SEC)
0.00
0.34
0.61
0.83
1.03
1.22
1.39
1.54
1.69
ENCOUNTER FREQ. (RAD/SEC)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
VERT. BENDING MT. AMIDSHIP (TON-FT)(X10³)
0.00
40.00
80.00
120.00
160.00
200.00
240.00


M/V STEWART J. CORT
TRANSFER FUNCTION
DRAFT FWD = 19FT11IN
AFT = 22FT 0IN
SHIP SPEED = 11.6 MPH
HEADING ANGLE = 20.°
ABSOLUTE FREQ. (RAD/SEC)
0.00
0.34
0.61
0.85
1.05
1.24
1.41
1.57
1.72
ENCOUNTER FREQ. (RAD/SEC)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
VERT. BENDING MT. AMIDSHIP (TON-FT)(X10³)
0.00
60.00
120.00
180.00
240.00
300.00
360.00

Part B

Update - "M/V STEWART J. CORT Full Scale Measurements-
Comparison of Vertical Bending Moments Amidships"
3 September 1980

American Bureau of Shipping
Sixty-five Broadway
New York, N.Y. 10006

Refer to DL/HHC/ml
File Ref. RD-3

3 September 1980

Captain H.M. Veillette
Chief, Marine Technology Division
U.S. Coast Guard
Washington, DC 20593

Subject: M/V STEWART J. CORT Full-Scale Measurement-
Comparison of Vertical Bending Moments Amidships

Dear Captain Veillette:

This is to acknowledge receipt of your letter of 19 August 1980, addressed to our Dr. H.H. Chen, regarding the subject matter. In your letter you forwarded materials on the comparison of measured vertical bending moments amidships with the results calculated by ABS and Webb Institute for the subject ship. It was also requested that we provide you with the low frequency dynamic bending moments computed with the program ABS/SHIPMOTION. We have reviewed the comparison, and offer the following comments:

1) The transfer function of vertical bending moment that we provided for the comparison was calculated by our program SPRINGSEA-II. The agreement between our results and the measured data in the high frequency (springing) range, as well as the significant value of springing bending moment is, indeed, very encouraging.

2) The bending moment transfer functions computed by the program SPRINGSEA-II are also valid in the low frequency range. In order to demonstrate this point, we have employed ABS/SHIPMOTION to calculate the low frequency transfer functions for the 8 conditions which are considered in the comparison. Results obtained are superimposed over the transfer functions generated by SPRINGSEA-II, mentioned in item 1. These results are displayed in Figures 1-8 enclosed herewith. Very close agreement is evident. On account of the confidence accorded to the ABS/SHIPMOTION results, the transfer functions of SPRINGSEA-II in the low frequency range are thus judged to be correct.

TELEPHONE 212-440 0300 CABLE ADDRESS "RECORD" TWX 710 581 3089 TELEX ITT 421966 RCA 232099 WUI 620353

3) We understand that the transfer function deduced from measured data is taken to be the square root of the measured bending moment spectrum divided by the measured wave height spectrum. It is expected, in general, that reliable results can be obtained from this procedure, provided that both bending moment and wave spectral ordinates are sufficiently large for producing non-biased data. This is not the case in the low frequency range of all 8 cases under consideration as evidenced by the small values of the wave spectra transmitted to us by your letter of 2 June 1980. In all cases, the wave energy in the low frequency range is seen to be extremely small. Hence, comparison should not be made in this range, unless similar data can be gathered under much more severe sea conditions where significant wave energy exists in the lower end of the wave spectrum.

4) Possible discrepancy between the analytical results obtained from Webb's computer program and the ABS programs had been suspected during the course of development of the ABS 1978 Great Lakes Bulk Carrier Rule for longitudinal strength. Attempting to resolve this issue, we had requested and subsequently received a program from the Coast Guard. This program was developed by Mr. T. Zelinsky at Webb, which, as we understand, is for head seas only. Previous comparison for Great Lakes vessels in head seas indicated that agreement between programs in our possession and SPRINGSEA-II were quite good in the high frequency range. This is illustrated for the Cort in a ballast condition by the display of Figure 9 enclosed. In the low frequency range, the Webb formulation is not expected to be valid and the agreements are poor. This point was established through our communication with Mr. Zelinsky at that time. In regards to the poor agreement between the analytical results obtained by ABS and Webb as exhibited in the comparison, it can be traced to a number of possible sources, among which are the appropriate use of the Webb program in non-head seas conditions and the discrepancies among the several versions of Webb's program. We have no ready means to investigate these possibilities.

We believe the enclosed comments will provide some explanation as to the differences between the calculated and measured bending moment transfer functions. If you have any questions regarding our comments, please do not hesitate to contact Dr. H.H. Chen at (201) 440-0466.

Very truly yours,

AMERICAN BUREAU OF SHIPPING

Stanley G. Stiansen
Vice President

By: Donald Liu
Donald Liu
Chief Research Engineer

Encl:

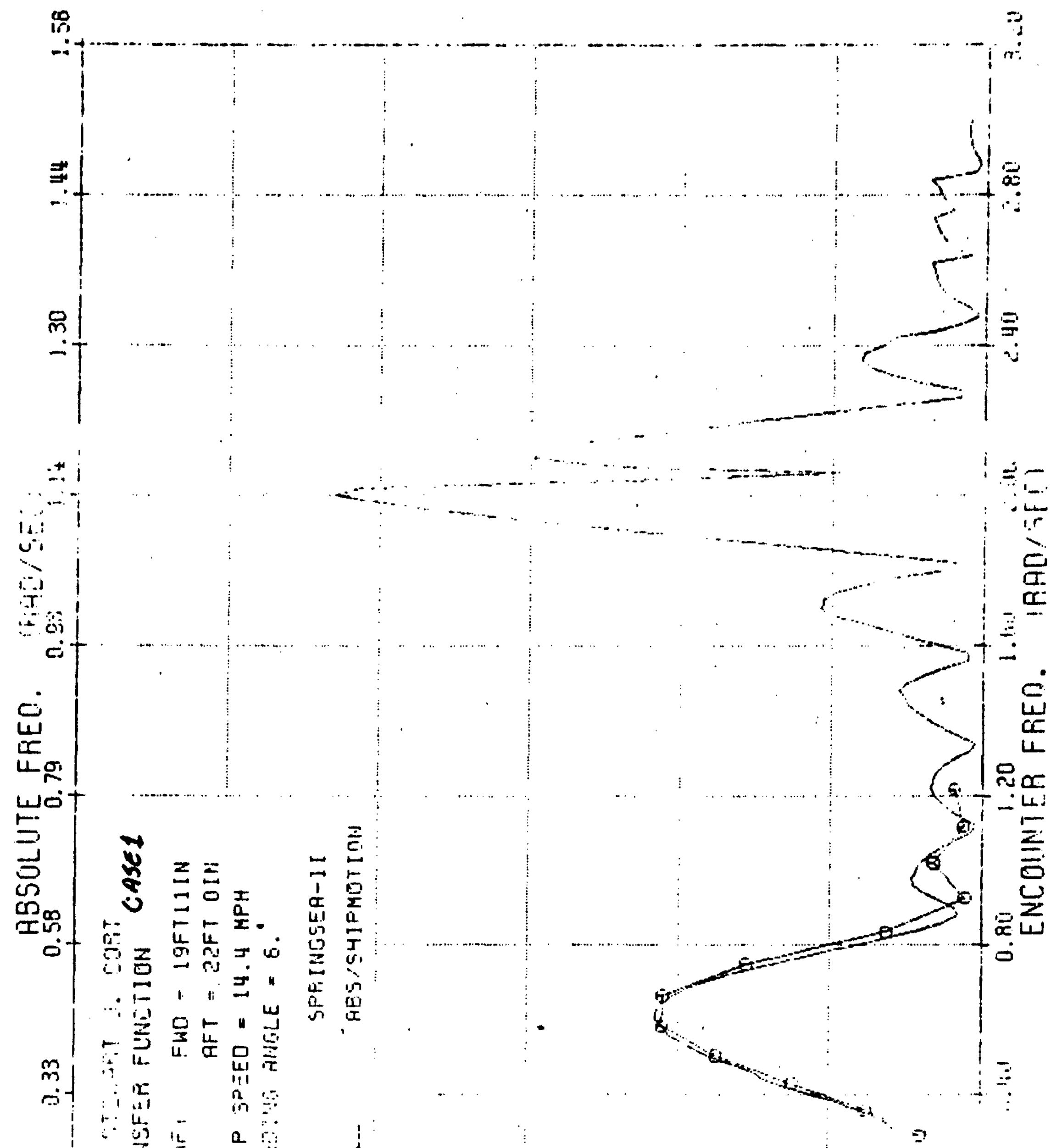

ABSOLUTE FREQ.
ENCOUNTER FREQ. (RAD/SEC)
TRANSFER FUNCTION CASE 1
FWD = 19FT11IN
AFT = 22FT 0IN
SHIP SPEED = 14.4 MPH
SPRINGSEA-II
ABS/SHIPMOTION
0.00
0.33
0.58
0.79
0.93
1.30
1.44
1.56
0.80
1.20
1.60
2.40
2.80
40.00
160.00
200.00
240.00

Fig. 1.

ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)
0.30	0.26	22249.	0.98	0.68	18539.	1.66	1.00	31174.	2.34	1.28	29858.
0.32	0.27	24137.	1.00	0.69	17710.	1.68	1.01	40817.	2.36	1.28	32542.
0.34	0.29	27397.	1.02	0.70	16412.	1.70	1.02	42751.	2.38	1.29	32176.
0.36	0.30	32222.	1.04	0.71	13980.	1.72	1.03	42270.	2.40	1.30	26436.
0.38	0.32	38155.	1.06	0.72	10764.	1.74	1.04	39007.	2.42	1.31	24389.
0.40	0.33	44677.	1.08	0.73	7046.	1.76	1.05	32647.	2.44	1.31	12079.
0.42	0.34	51260.	1.10	0.74	3004.	1.78	1.05	23385.	2.46	1.32	5603.
0.44	0.36	57367.	1.12	0.75	1521.	1.80	1.06	9221.	2.48	1.33	1539.
0.46	0.37	60027.	1.1[illegible]	0.76	5213.	1.82	1.07	7478.	2.50	1.34	4396.
0.48	0.38	65714.	1.16	0.77	8480.	1.84	1.08	26690.	2.52	1.34	8050.
0.50	0.40	71117.	1.18	[illegible]	10[illegible]46.	1.86	1.09	46123.	2.54	1.35	10740.
0.52	0.41	75709.	1.20	0.79	12619.	1.88	1.10	66366.	2.56	1.36	12340.
0.54	0.42	79216.	1.22	0.80	13428.	1.90	1.10	87088.	2.58	1.36	13252.
0.56	0.44	82835.	1.24	0.81	13313.	1.92	1.11	107415.	2.60	1.37	13677.
0.58	0.45	83445.	1.26	0.82	12251.	1.94	1.12	126580.	2.62	1.38	14223.
0.60	0.46	85955.	1.28	0.83	10201.	1.96	1.13	143821.	2.64	1.39	4048.
0.62	0.47	86070.	1.30	0.84	7249.	1.98	1.14	159333.	2.66	1.39	5725.
0.64	0.49	84885.	1.32	0.85	3684.	2.00	1.14	172138.	2.68	1.40	10686.
0.66	0.50	82317.	1.34	0.86	2110.	2.02	1.15	165239.	2.70	1.41	12380.
0.68	0.51	78441.	1.36	0.87	6332.	2.04	1.16	96036.	2.72	1.41	13218.
0.70	0.52	73200.	1.38	0.88	10334.	2.06	1.17	38035.	2.74	1.42	13976.
0.72	0.53	66626.	1.40	0.89	13927.	2.08	1.18	102358.	2.76	1.43	8712.
0.74	0.55	58827.	1.42	0.90	16739.	2.10	1.18	119274.	2.78	1.44	10433.
0.76	0.56	50449.	1.44	0.91	19543.	2.12	1.19	116822.	2.80	1.44	11906.
0.78	0.57	41537.	1.46	0.91	20464.	2.14	1.20	106550.	2.82	1.45	12694.
0.80	0.58	32466.	1.48	0.92	22035.	2.16	1.21	91910.	2.84	1.46	14711.
0.82	0.59	23984.	1.50	0.93	19834.	2.18	1.22	74936.	2.86	1.46	3182.
0.84	0.60	16238.	1.52	0.94	15840.	2.20	1.22	60080.	2.88	1.47	1490.
0.86	0.61	10632.	1.54	0.95	10429.	2.22	1.23	41055.	2.90	1.48	2902.
0.88	0.62	6518.	1.56	0.96	3739.	2.24	1.24	24109.	2.92	1.48	3959.
0.90	0.64	7277.	1.58	0.97	3956.	2.26	1.25	6230.	2.94	1.49	4587.
0.92	0.65	11103.	1.60	0.98	11358.	2.28	1.25	6815.	2.96	1.50	4772.
0.94	0.66	15012.	1.62	0.99	18711.	2.30	1.26	17156.	2.98	1.50	4740.
0.96	0.67	17837.	1.64	0.99	25730.	2.32	1.27	24950.	3.00	1.51	4576.

M/V STEWART J. CORT

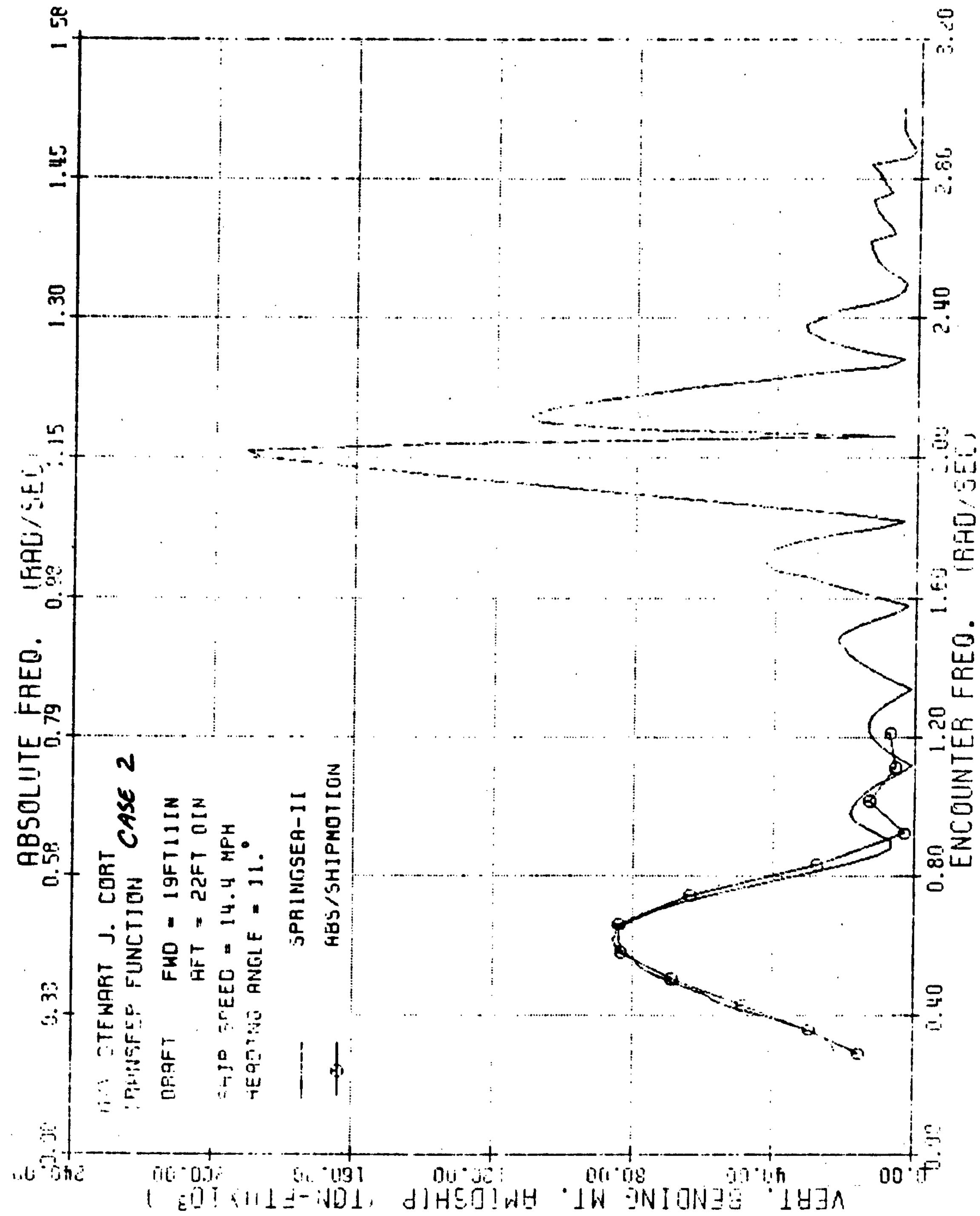
TRANSFER FUNCTION

DRAFT FWD = 19FT11IN

AFT = 22FT 0IN

SHIP SPEED = 14.4 MPH

HEADING ANGLE = 6.°



ABSOLUTE FREQ. (RAD/SEC)
STEWART J. CORT
TRANSFER FUNCTION CASE 2
DRAFT FWD = 19FT11IN
AFT = 22FT 0IN
SHIP SPEED = 14.4 MPH
HEADING ANGLE = 11.°
SPRINGSEA-II
ABS/SHIPMOTION
ENCOUNTER FREQ. (RAD/SEC)
VERT. BENDING MT. AMIDSHIP (TON-FT)(10^3)

Fig. 2

ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)
0.30	0.26	22504.	0.98	0.68	18275.	1.66	1.01	30353.	2.34	1.28	28737.
0.32	0.27	23121.	1.00	0.69	17661.	1.68	1.02	40388.	2.36	1.29	31566.
0.34	0.29	26045.	1.02	0.70	16157.	1.70	1.02	42979.	2.38	1.30	32074.
0.36	0.30	30988.	1.04	0.71	14197.	1.72	1.03	43170.	2.40	1.30	27205.
0.38	0.32	36674.	1.06	0.72	[illegible]	1.74	1.04	40631.	2.42	1.31	23202.
0.40	0.33	47960	1.08	0.73	7514.	1.76	1.05	34975.	2.44	1.32	13303.
0.42	0.34	50973.	1.10	0.74	3555.	1.78	1.06	24649.	2.46	1.33	6673.
0.44	0.36	56549.	1.12	0.75	986.	1.80	1.07	11425.	2.48	1.33	3813.
0.46	0.37	59138.	1.14	0.76	4638.	1.82	1.08	3600.	2.50	1.34	3610.
0.48	0.38	64794.	1.16	0.77	7989.	1.84	1.08	18659.	2.52	1.35	6490.
0.50	0.40	70186.	1.18	0.78	10557.	1.86	1.09	41387.	2.54	1.36	9583.
0.52	0.41	74789.	1.20	0.79	12369.	1.88	1.10	62680.	2.56	1.36	11671.
0.54	0.42	78146.	1.22	0.80	13333.	1.90	1.11	84352.	2.58	1.37	12960.
0.56	0.44	79616.	1.24	0.81	13324.	1.92	1.12	106123.	2.60	1.38	13571.
0.58	0.45	82413.	1.26	0.82	12432.	1.94	1.12	127326.	2.62	1.38	14143.
0.60	0.46	85142.	1.28	0.83	10563.	1.96	1.13	147357.	2.64	1.39	7184.
0.62	0.47	85579.	1.30	0.84	7775.	1.98	1.14	166432.	2.66	1.40	8119.
0.64	0.49	84606.	1.32	0.85	4384.	2.00	1.15	186983.	2.68	1.41	9933.
0.66	0.50	82247.	1.34	0.86	1299.	2.02	1.16	191034.	2.70	1.41	11618.
0.68	0.51	78579.	1.36	0.87	5581.	2.04	1.17	135582.	2.72	1.42	12886.
0.70	0.52	73554.	1.38	0.88	9632.	2.06	1.17	6689.	2.74	1.43	13245.
0.72	0.54	67190.	1.40	0.89	13340.	2.08	1.18	81590.	2.76	1.43	7860.
0.74	0.55	59581.	1.42	0.90	16372.	2.10	1.19	107609.	2.78	1.44	9423.
0.76	0.56	51361.	1.44	0.91	19342.	2.12	1.20	110474.	2.80	1.45	10911.
0.78	0.57	42567.	1.46	0.92	20458.	2.14	1.20	103864.	2.82	1.46	11850.
0.80	0.58	33591.	1.48	0.93	22335.	2.16	1.21	91835.	2.84	1.46	13921.
0.82	0.59	24955.	1.50	0.94	20610.	2.18	1.22	76710.	2.86	1.47	3307.
0.84	0.60	17143.	1.52	0.94	16945.	2.20	1.23	63262.	2.88	1.48	1353.
0.86	0.62	10780.	1.54	0.95	11797.	2.22	1.24	43215.	2.90	1.48	2798.
0.88	0.63	6775.	1.56	0.96	5474.	2.24	1.24	28267.	2.92	1.49	3937.
0.90	0.64	6749.	1.58	0.97	2275.	2.26	1.25	9011.	2.94	1.50	4632.
0.92	0.65	10210.	1.60	0.98	9784.	2.28	1.26	3591.	2.96	1.50	4909.
0.94	0.66	14086.	1.62	0.99	17229.	2.30	1.27	14104.	2.98	1.51	4934.
0.96	0.67	17267.	1.64	1.00	24268.	2.32	1.27	22450.	3.00	1.52	4896.

M/V STEWART J. CORT

TRANSFER FUNCTION

DRAFT FWD = 19FT11IN

AFT = 22FT 0IN

SHIP SPEED = 14.4 MPH

HEADING ANGLE = 11.°

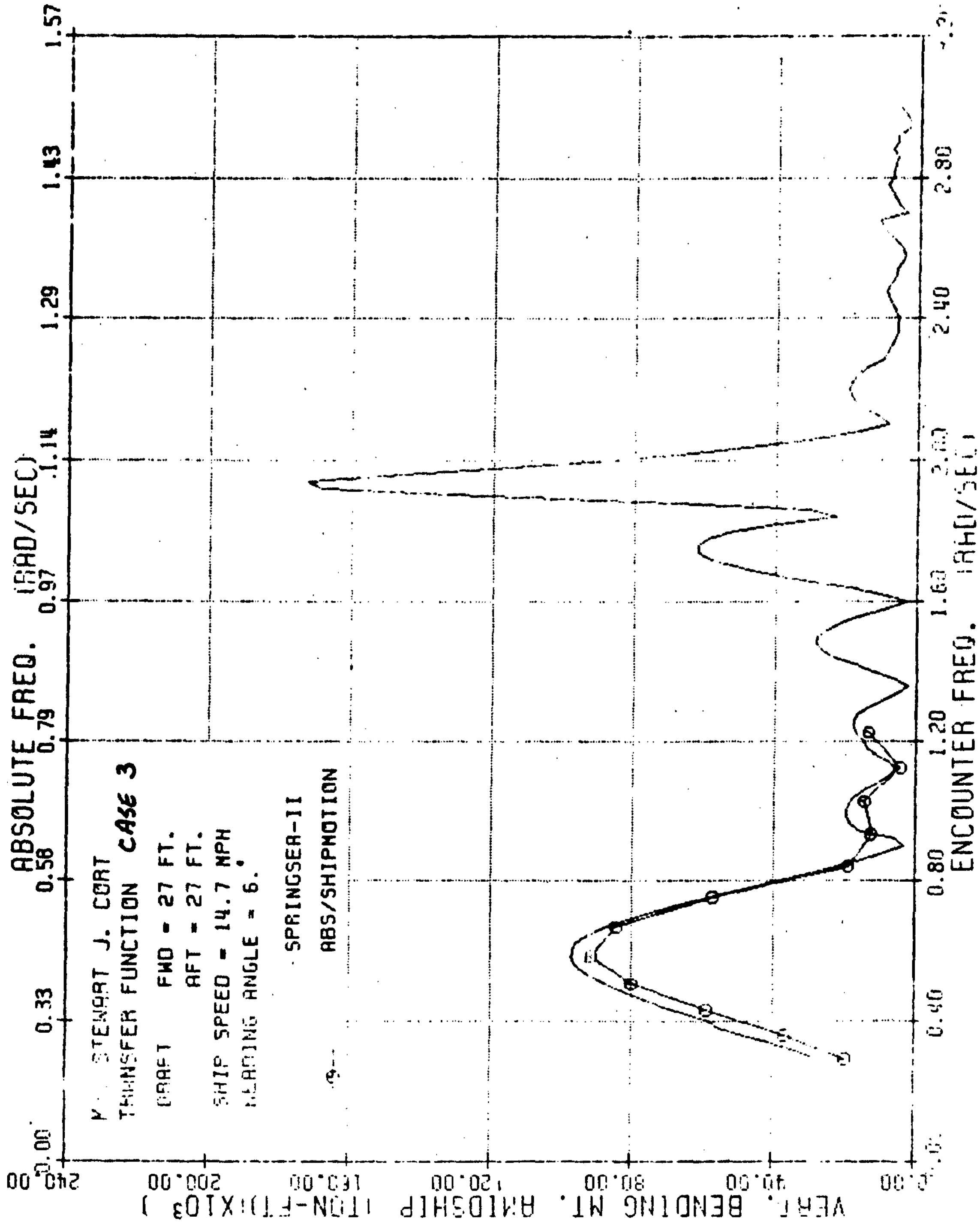

M. STEWART J. CORT
TRANSFER FUNCTION CASE 3
DRAFT FWD = 27 FT.
AFT = 27 FT.
SHIP SPEED = 14.7 MPH
HEADING ANGLE = 6.°
SPRINGSEA-II
ABS/SHIPMOTION
ABSOLUTE FREQ. (RAD/SEC)
ENCOUNTER FREQ. (RAD/SEC)
VERT. BENDING MT. AMIDSHIP (TON-FT)(X10³)
0.00
0.33
0.56
0.79
0.97
1.14
1.29
1.43
1.57
0.40
0.80
1.20
1.60
2.40
2.80
240.00
200.00
160.00
120.00
80.00
40.00
0.00

Fig. 3

ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)
0.30	0.26	29255.	0.98	0.68	17527.	1.66	1.00	32262.	2.34	1.27	6707.
0.32	0.27	34706.	1.00	0.69	[illegible]	1.68	1.01	43159.	2.36	1.28	6160.
0.34	0.29	41393.	1.02	0.70	18985.	1.70	1.01	51436.	2.38	1.28	5961.
0.36	0.30	48427.	1.04	0.71	[illegible]	1.72	1.02	57870.	2.40	1.29	6197.
0.38	0.31	55135.	1.06	0.72	14249.	1.74	1.03	61885.	2.42	1.30	6823.
0.40	0.33	58006.	1.08	0.73	10721.	1.76	1.04	62106.	2.44	1.31	7737.
0.42	0.34	64437.	1.10	0.74	7510.	1.78	1.05	59265.	2.46	1.31	6638.
0.44	0.36	70843.	1.12	0.75	5651.	1.80	1.06	52012.	2.48	1.32	9276.
0.46	0.37	75854.	1.14	0.76	7721.	1.82	1.06	39472.	2.50	1.33	9178.
0.48	0.38	81356.	1.16	0.77	11002.	1.84	1.07	22925.	2.52	1.33	6358.
0.50	0.40	86367.	1.18	0.78	14114.	1.86	1.08	30296.	2.54	1.34	6517.
0.52	0.41	90112.	1.20	0.79	14912.	1.88	1.09	68939.	2.56	1.35	4666.
0.54	0.42	93457.	1.22	0.80	16716.	1.90	1.10	122563.	2.58	1.36	3834.
0.56	0.43	96139.	1.24	0.81	17624.	1.92	1.11	168401.	2.60	1.36	4745.
0.58	0.45	97063.	1.26	0.82	17726.	1.94	1.11	172399.	2.62	1.37	[illegible]
0.60	0.46	96785.	1.28	[illegible]	16536.	1.96	1.12	145871.	2.64	1.38	[illegible]
0.62	0.47	95813.	1.30	0.84	13197.	1.98	1.13	114985.	2.66	1.38	[illegible]
0.64	0.48	93074.	1.32	0.84	[illegible]	2.00	1.14	87210.	2.68	1.39	[illegible]
0.66	0.50	88806.	1.34	0.85	5132.	2.02	1.15	63443.	2.70	1.40	3550.
0.68	0.51	83586.	1.36	0.86	2321.	2.04	1.15	44327.	2.72	1.40	5652.
0.70	0.52	77334.	1.38	0.87	6777.	2.06	1.16	28242.	2.74	1.41	6943.
0.72	0.53	70262.	1.40	0.88	12585.	2.08	1.17	16778.	2.76	1.42	8182.
0.74	0.54	62681.	1.42	0.89	17079.	2.10	1.18	8276.	2.78	1.43	9024.
0.76	0.55	54719.	1.44	0.90	23394.	2.12	1.18	10931.	2.80	1.43	7569.
0.78	0.57	46532.	1.46	0.91	26497.	2.14	1.19	14557.	2.82	1.44	7770.
0.80	0.58	38284.	1.48	0.92	28493.	2.16	1.20	17449.	2.84	1.45	7176.
0.82	0.59	30189.	1.50	0.93	27825.	2.18	1.21	19045.	2.86	1.45	6271.
0.84	0.60	22333.	1.52	0.94	25512.	2.20	1.22	19739.	2.88	1.46	7946.
0.86	0.61	15027.	1.54	0.94	21433.	2.22	1.22	18774.	2.90	1.47	6563.
0.88	0.62	8937.	1.56	0.95	15639.	2.24	1.23	17011.	2.92	1.47	6580.
0.90	0.63	3198.	1.58	0.96	8496.	2.26	1.24	14670.	2.94	1.48	3197.
0.92	0.64	5761.	1.60	0.97	2846.	2.28	1.25	10390.	2.96	1.49	3310.
0.94	0.65	15614.	1.62	0.98	10248.	2.30	1.25	9040.	2.98	1.49	3951.
0.96	0.67	18396.	1.64	0.99	19243.	2.32	1.26	8106.	3.00	1.50	5934.

M/V STEWART J. CORT

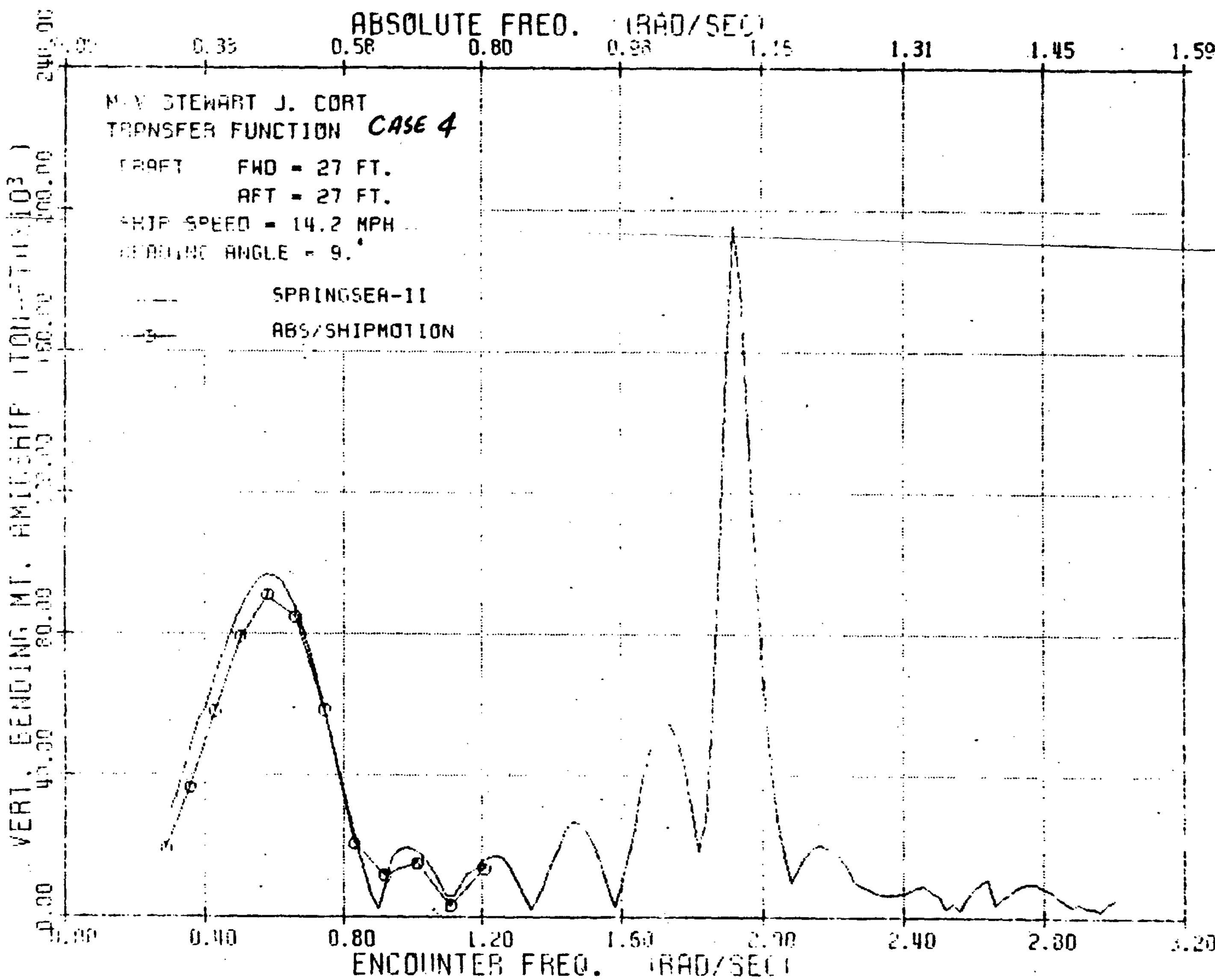
TRANSFER FUNCTION

DRAFT FWD = 27 FT.

AFT = 27 FT.

SHIP SPEED = 14.7 MPH

HEADING ANGLE = 6.°



ABSOLUTE FREQ. (RAD/SEC)
0.58
0.80
1.31
1.45
1.59
M/V STEWART J. CORT
TRANSFER FUNCTION CASE 4
DRAFT FWD = 27 FT.
AFT = 27 FT.
SHIP SPEED = 14.2 MPH
HEADING ANGLE = 9.
SPRINGSEA-II
ABS/SHIPMOTION
VERT. BENDING MT. AMIDSHIP (TON-FT×10³)
80.00
0.40
0.80
1.20
2.40
2.80
ENCOUNTER FREQ. (RAD/SEC)

Fig. 4

ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)
0.30	0.26	29523.	0.98	0.68	19591.	1.66	1.01	38788.	2.34	1.28	6439.
0.32	0.27	35207.	1.00	0.69	17150.	1.68	1.02	46103.	2.36	1.29	6361.
0.34	0.29	41880.	1.02	0.70	13927.	1.70	1.03	51520.	2.38	1.30	6457.
0.36	0.30	48959.	1.04	0.71	15699.	1.72	1.04	54477.	2.40	1.31	6988.
0.38	0.32	55705.	1.06	0.72	12601.	1.74	1.04	54454.	2.42	1.31	7746.
0.40	0.33	58814.	1.08	0.73	9136.	1.76	1.05	50339.	2.44	1.32	8466.
0.42	0.34	65236.	1.10	0.75	6097.	1.78	1.06	42852.	2.46	1.33	8773.
0.44	0.36	71613.	1.12	0.76	6192.	1.80	1.07	31095.	2.48	1.34	7200.
0.46	0.37	76588.	1.14	0.77	9003.	1.82	1.08	18630.	2.50	1.34	5972.
0.48	0.39	82017.	1.16	0.78	12251.	1.84	1.09	26922.	2.52	1.35	2439.
0.50	0.40	86723.	1.18	0.79	13313.	1.86	1.09	57981.	2.54	1.36	4108.
0.52	0.41	90542.	1.20	0.80	15514.	1.88	1.10	102756.	2.56	1.37	2175.
0.54	0.42	93717.	1.22	0.81	16798.	1.90	1.11	156224.	2.58	1.37	5484.
0.56	0.44	96184.	1.24	0.82	17256.	1.92	1.12	195727.	2.60	1.38	7345.
0.58	0.45	96875.	1.26	0.82	16630.	1.94	1.13	179259.	2.62	1.39	9767.
0.60	0.46	96327.	1.28	0.83	14028.	1.96	1.14	139414.	2.64	1.40	10917.
0.62	0.48	94719.	1.30	0.84	10542.	1.98	1.14	101050.	2.66	1.40	3416.
0.64	0.49	91734.	1.32	0.85	6446.	2.00	1.15	69841.	2.68	1.41	5563.
0.66	0.50	87221.	1.34	0.86	2162.	2.02	1.16	45255.	2.70	1.42	6930.
0.68	0.51	81747.	1.36	0.87	5101.	2.04	1.17	27506.	2.72	1.42	8235.
0.70	0.52	75253.	1.38	0.88	9688.	2.06	1.18	17727.	2.74	1.43	9169.
0.72	0.54	67965.	1.40	0.89	15031.	2.08	1.18	9797.	2.76	1.44	9618.
0.74	0.55	60082.	1.42	0.90	18870.	2.10	1.19	13941.	2.78	1.45	9531.
0.76	0.56	51989.	1.44	0.91	24284.	2.12	1.20	17392.	2.80	1.45	7969.
0.78	0.57	43736.	1.46	0.92	26902.	2.14	1.21	19643.	2.82	1.46	7679.
0.80	0.58	35477.	1.48	0.93	26467.	2.16	1.22	20325.	2.84	1.47	5718.
0.82	0.59	27442.	1.50	0.94	24532.	2.18	1.22	19511.	2.86	1.47	4572.
0.84	0.61	19727.	1.52	0.95	20893.	2.20	1.23	18973.	2.88	1.48	3050.
0.86	0.62	12645.	1.54	0.96	15595.	2.22	1.24	16641.	2.90	1.49	3897.
0.88	0.63	6303.	1.56	0.96	8959.	2.24	1.25	14049.	2.92	1.49	2719.
0.90	0.64	2450.	1.58	0.97	2738.	2.26	1.25	9870.	2.94	1.50	2611.
0.92	0.65	8547.	1.60	0.98	8618.	2.28	1.26	8708.	2.96	1.51	2119.
0.94	0.66	16623.	1.62	0.99	16980.	2.30	1.27	7832.	2.98	1.51	3804.
0.96	0.67	18745.	1.64	1.00	25179.	2.32	1.28	6947.	3.00	1.52	5157.

M/V STEWART J. CORT

TRANSFER FUNCTION

DRAFT FWD = 27 FT.

AFT = 27 FT.

SHIP SPEED = 14.2 MPH

HEADING ANGLE = 9.

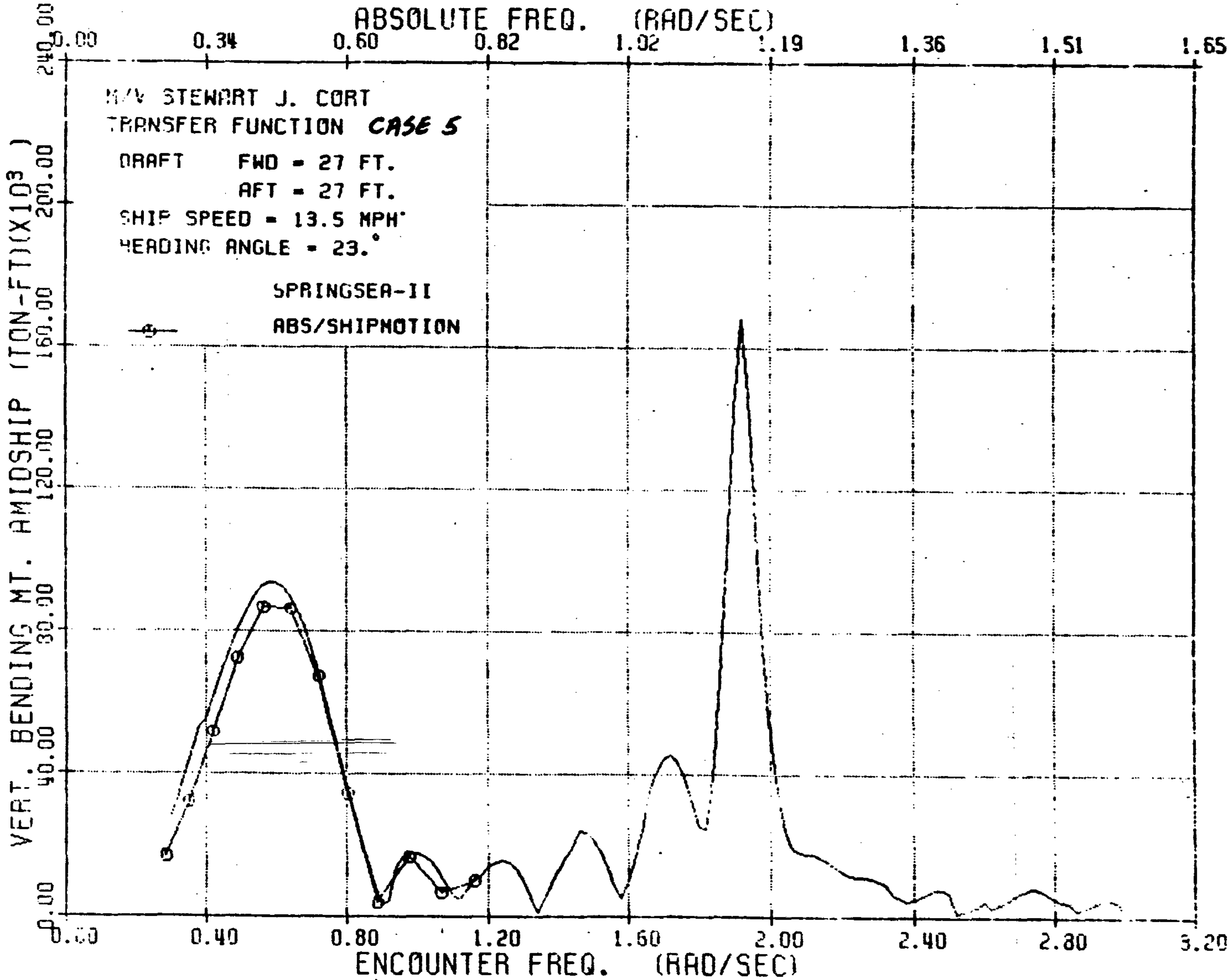

ABSOLUTE FREQ. (RAD/SEC)
0.00
0.34
0.60
0.82
1.02
1.19
1.36
1.51
1.65
M/V STEWART J. CORT
TRANSFER FUNCTION CASE 5
DRAFT FWD = 27 FT.
AFT = 27 FT.
SHIP SPEED = 13.5 MPH
HEADING ANGLE = 23.°
SPRINGSEA-II
ABS/SHIPMOTION
VERT. BENDING MT. AMIDSHIP (TON-FT)(X10³)
240.00
200.00
160.00
120.00
80.00
40.00
0.00
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
ENCOUNTER FREQ. (RAD/SEC)

Fig. 5

ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)
0.30	0.26	28169.	0.98	0.70	17778.	1.66	1.04	35057.	2.34	1.33	6254.
0.32	0.28	33643.	1.00	0.7[illegible]	17764.	1.68	[illegible]	40107.	2.36	1.34	5124.
0.34	0.29	40012.	1.02	0.72	16956.	1.70	[illegible]	44041.	2.38	1.35	4413.
0.36	0.31	46781.	1.04	0.73	15023.	1.72	1.07	45437.	2.40	1.36	4676.
0.38	0.32	53234.	1.06	0.75	12290.	1.74	1.08	43605.	2.42	1.36	5715.
0.40	0.34	55254.	1.08	0.76	9069.	1.76	1.09	39272.	2.44	1.37	6836.
0.42	0.35	61449.	1.10	0.77	5871.	1.78	1.10	32824.	2.46	1.38	7556.
0.44	0.36	67650.	1.12	0.78	4215.	1.80	1.11	25508.	2.48	1.39	[illegible]
0.46	0.38	72508.	1.14	0.79	[illegible]488.	1.82	1.12	24597.	2.50	1.40	[illegible]
0.48	0.39	77885.	1.16	0.80	10436.	1.84	1.12	39060.	2.52	1.40	[illegible]
0.50	0.41	82817.	1.18	0.81	11674.	1.86	1.13	66301.	2.54	1.41	1718.
0.52	0.42	86537.	1.20	0.82	13856.	1.88	1.14	100672.	2.56	1.42	2398.
0.54	0.43	89896.	1.22	0.83	15183.	1.90	1.15	142685.	2.58	1.43	2726.
0.56	0.45	92637.	1.24	0.84	15732.	1.92	1.16	167948.	2.60	1.43	4558.
0.58	0.46	93651.	1.26	0.85	15066.	1.94	1.17	146766.	2.62	1.44	2595.
0.60	0.47	93514.	1.28	0.86	13005.	1.96	1.18	109093.	2.64	1.45	3574.
0.62	0.49	92378.	1.30	0.87	9893.	1.98	1.18	75929.	2.66	1.46	4177.
0.64	0.50	89912.	1.32	0.88	5764.	2.00	1.19	51008.	2.68	1.46	5617.
0.66	0.51	85937.	1.34	0.89	1096.	2.02	1.20	35351.	2.70	1.47	6843.
0.68	0.52	81024.	1.36	0.90	4730.	2.04	1.21	24435.	2.72	1.48	7644.
0.70	0.54	75083.	1.38	0.91	9139.	2.06	1.22	19201.	2.74	1.49	7893.
0.72	0.55	68319.	1.40	0.92	13353.	2.08	1.23	17901.	2.76	1.49	7517.
0.74	0.56	60891.	1.42	0.93	16867.	2.10	1.24	17703.	2.78	1.50	6361.
0.76	0.57	53232.	1.44	0.94	19361.	2.12	1.24	17788.	2.80	1.51	5335.
0.78	0.59	45331.	1.46	0.95	24096.	2.14	1.25	16300.	2.82	1.52	4368.
0.80	0.60	37368.	1.48	0.96	23527.	2.16	1.26	15656.	2.84	1.52	3894.
0.82	0.61	29541.	1.50	0.97	21720.	2.18	1.27	13849.	2.86	1.53	2102.
0.84	0.62	21929.	1.52	0.98	18419.	2.20	1.28	12289.	2.88	1.54	2431.
0.86	0.63	14840.	1.54	0.99	13774.	2.22	1.28	11433.	2.90	1.55	3333.
0.88	0.64	8372.	1.56	1.00	8390.	2.24	1.29	11153.	2.92	1.55	4189.
0.90	0.66	3214.	1.58	1.01	5340.	2.26	1.30	11119.	2.94	1.56	4716.
0.92	0.67	4370.	1.60	1.02	9744.	2.28	1.31	10840.	2.96	1.57	4796.
0.94	0.68	14034.	1.62	1.02	16945	2.30	1.32	10178.	2.98	1.57	4344.
0.96	0.69	16656.	1.64	1.03	23867.	2.32	1.33	9067.	3.00	1.58	1115.

M/V STEWART J. CORT

TRANSFER FUNCTION

DRAFT FWD = 27 FT.

AFT = 27 FT.

SHIP SPEED = 13.5 MPH

HEADING ANGLE = 23.°

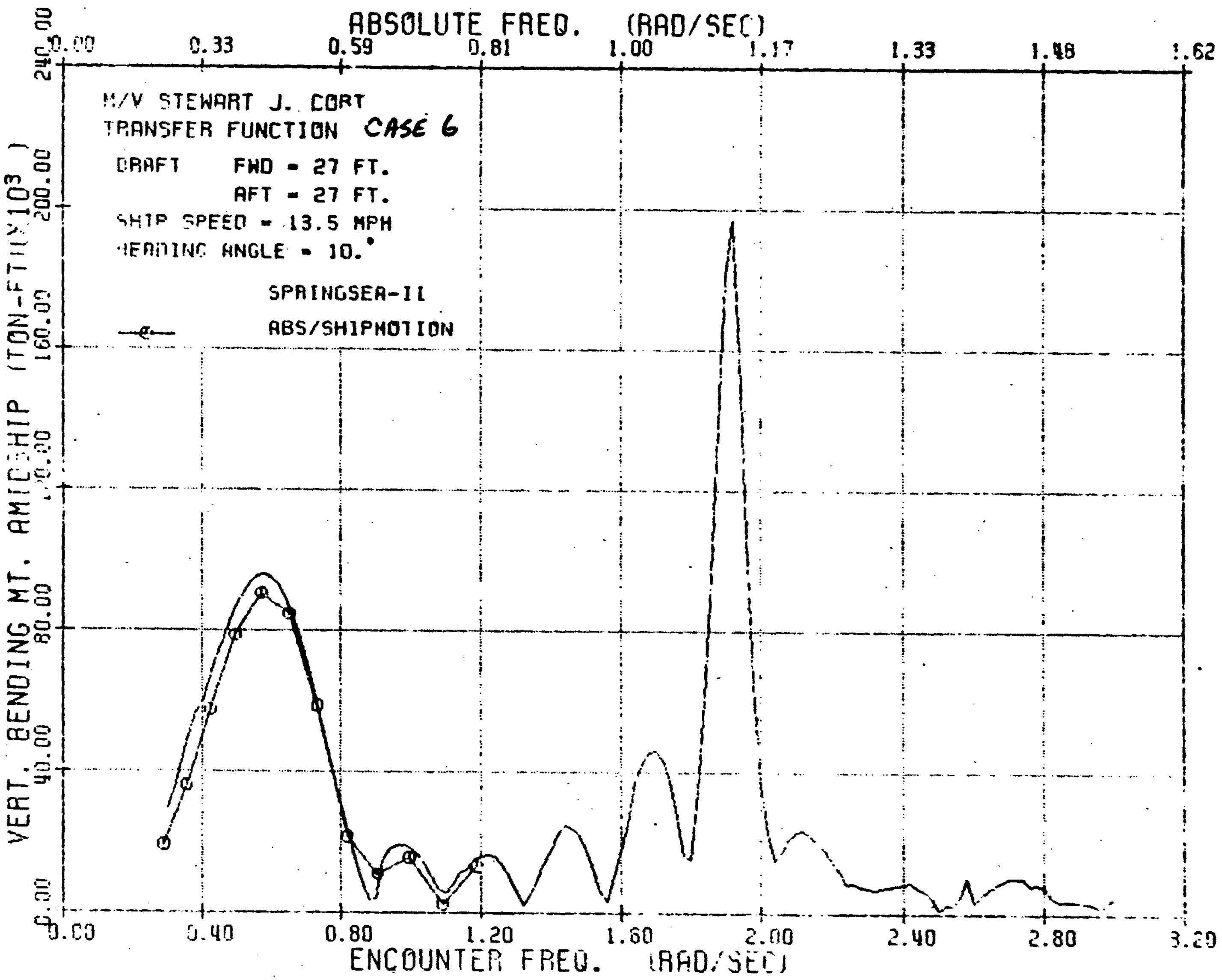

ABSOLUTE FREQ. (RAD/SEC)
0.00
0.33
0.59
0.81
1.00
1.17
1.33
1.48
1.62
M/V STEWART J. CORT
TRANSFER FUNCTION CASE 6
DRAFT FWD = 27 FT.
AFT = 27 FT.
SHIP SPEED = 13.5 MPH
HEADING ANGLE = 10.°
SPRINGSEA-II
ABS/SHIPMOTION
VERT. BENDING MT. AMIDSHIP (TON-FT)(X10³)
240.00
200.00
160.00
80.00
40.00
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
ENCOUNTER FREQ. (RAD/SEC)

Fig. 6

ω_c (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)
0.30	0.26	29626.	0.98	[illegible]	[illegible]	1.66	1.02	42490.	2.34	1.31	7140.
0.32	0.27	35342.	1.00	0.70	[illegible]	1.68	1.03	45595.	2.36	1.31	7640.
0.34	0.29	42891.	1.02	0.71	16870.	1.70	1.04	46063.	2.38	1.32	7925.
0.36	0.30	50020.	1.04	0.72	13434.	1.72	1.05	43430.	2.40	1.33	8185.
0.38	0.32	56308.	1.06	0.73	9751.	1.74	1.06	37493.	2.42	1.34	8706.
0.40	0.33	59161.	1.08	0.74	[illegible]	1.76	1.07	27789.	2.44	1.34	[illegible]
0.42	0.35	65610.	1.10	0.75	5451.	1.78	1.08	16311.	2.46	1.35	6547.
0.44	0.36	71988.	1.12	0.77	8082.	1.80	1.09	15155.	2.48	1.36	4319.
0.46	0.37	76956.	1.14	0.78	[illegible]	1.82	1.09	34374.	2.50	1.37	970.
0.48	0.39	82322.	1.16	0.79	12331.	1.84	1.10	60938.	2.52	1.37	[illegible]
0.50	0.40	87119.	1.18	0.80	11676.	1.86	1.11	75928.	2.54	1.38	2558.
0.52	0.42	90593.	1.20	0.81	16072.	1.88	1.12	137616.	2.56	1.39	4800.
0.54	0.43	93555.	1.22	0.82	16531.	1.90	1.13	180927.	2.58	1.40	10139.
0.56	0.44	95735.	1.24	0.83	16100.	1.92	1.14	197000.	2.60	1.40	3030.
0.58	0.45	96112.	1.26	0.84	15691.	1.94	1.15	158230.	2.62	1.41	5226.
0.60	0.47	95193.	1.28	0.85	10233.	1.96	1.15	106872.	2.64	1.42	6724.
0.62	0.48	93161.	1.30	0.86	6236.	1.98	1.16	65403.	2.66	1.43	[illegible]
0.64	0.49	89721.	1.32	0.87	2060.	2.00	1.17	36891.	2.68	1.43	9251.
0.66	0.51	84753.	1.34	0.88	5050.	2.02	1.18	22683.	2.70	1.44	9824.
0.68	0.52	78814.	1.36	0.89	9460.	2.04	1.19	15217.	2.72	1.45	9852.
0.70	0.53	71881.	1.38	0.89	14531.	2.06	1.19	17428.	2.74	1.46	10087.
0.72	0.54	64204.	1.40	0.90	18059.	2.08	1.20	21156.	2.76	1.46	8185.
0.74	0.55	56032.	1.42	0.91	22832.	2.10	1.21	23280.	2.78	1.47	8383.
0.76	0.57	47706.	1.44	0.92	25000.	2.12	1.22	23529.	2.80	1.48	7654.
0.78	0.58	39336.	1.46	0.93	24161.	2.14	1.23	22073.	2.82	1.48	4945.
0.80	0.59	31072.	1.48	0.94	21858.	2.16	1.24	19887.	2.84	1.49	[illegible]
0.82	0.60	23174.	1.50	0.95	17940.	2.18	1.24	17950.	2.86	1.50	3454.
0.84	0.61	15748.	1.52	0.96	12470.	2.20	1.25	14870.	2.88	1.51	3214.
0.86	0.62	9091.	1.54	0.97	6004.	2.22	1.26	12091.	2.90	1.51	3505.
0.88	0.64	3576.	1.56	0.98	3386.	2.24	1.27	8600.	2.92	1.52	3251.
0.90	0.65	4119.	1.58	0.99	10561.	2.26	1.27	8556.	2.94	1.53	2680.
0.92	0.66	14870.	1.60	1.00	18194.	2.28	1.28	7529.	2.96	1.53	1624.
0.94	0.67	17919.	1.62	1.01	25325.	2.30	1.29	7018.	2.98	1.54	3303.
0.96	0.68	19164.	1.64	1.02	37204.	2.32	1.30	6897.	3.00	1.55	5357.

M/V STEWART J. CORT
TRANSFER FUNCTION

DRAFT FWD = 27 FT.
AFT = 27 FT.
SHIP SPEED = 13.5 MPH
HEADING ANGLE = 10.°

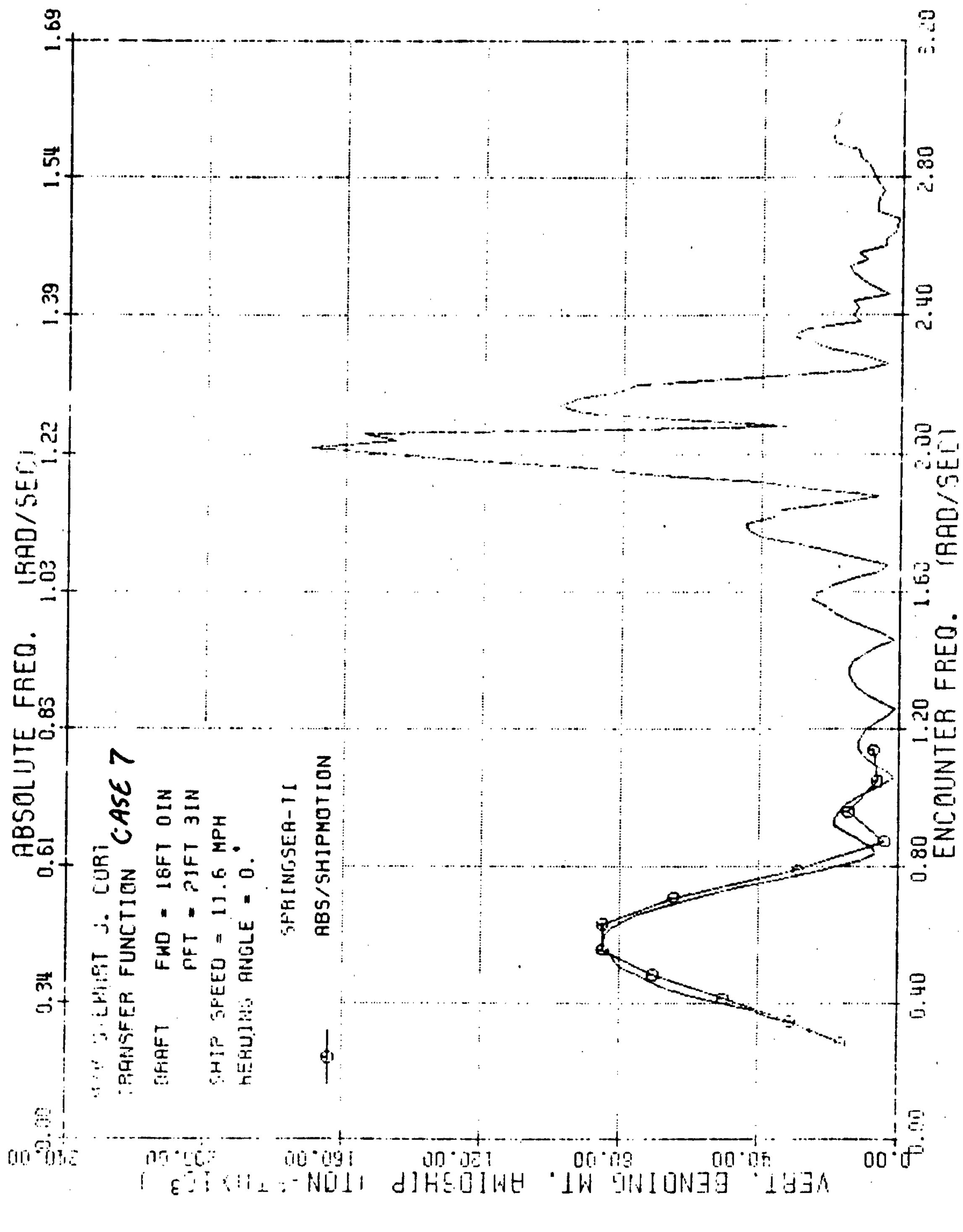

ABSOLUTE FREQ. (RAD/SEC)
0.00 0.34 0.61 0.83 1.03 1.22 1.39 1.54 1.69
TRANSFER FUNCTION CASE 7
DRAFT FWD = 16FT 0IN
AFT = 21FT 3IN
SHIP SPEED = 11.6 MPH
HEADING ANGLE = 0.°
SPRINGSEA-II
ABS/SHIPMOTION
ENCOUNTER FREQ. (RAD/SEC)
0.00 0.40 0.80 1.20 1.60 2.00 2.40 2.80
VERT. BENDING MT. AMIDSHIP
0.00 40.00 80.00 120.00 160.00 200.00 240.00

Fig. 7

ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)
0.30	0.26	23326.	0.98	0.71	15323.	1.66	1.06	5897.	2.34	1.36	32149.
0.32	0.28	25271.	1.00	0.72	11935.	1.68	1.07	3432.	2.36	1.37	26950.
0.34	0.29	28968.	1.02	0.73	8494.	1.70	1.08	12259.	2.38	1.38	12027.
0.36	0.31	36379.	1.04	0.75	4381.	1.72	1.09	20580.	2.40	1.39	13829.
0.38	0.32	41575.	1.06	0.76	1289.	1.74	1.10	29310.	2.42	1.39	12250.
0.40	0.34	50326.	1.08	0.77	4106.	1.76	1.11	39670.	2.44	1.40	13805.
0.42	0.35	~~58974.~~	~~1.10~~	0.78	7583.	1.78	1.12	43714.	2.46	1.41	3573.
0.44	0.37	65451.	1.12	0.79	10182.	1.80	1.13	44541.	2.48	1.42	7886.
0.46	0.38	70301.	1.14	0.80	11419.	1.82	1.14	36339.	2.50	1.43	11330.
0.48	0.40	74049.	1.16	0.81	11652.	1.84	1.15	34507.	2.52	1.43	14109.
0.50	0.41	78941.	1.18	0.82	10887.	1.86	1.15	17719.	2.54	1.44	15374.
0.52	0.42	81347.	1.20	0.83	9149.	1.88	1.16	5924.	2.56	1.45	10031.
0.54	0.44	82486.	1.22	0.84	6513.	1.90	1.17	25505.	2.58	1.46	12501.
0.56	0.45	84091.	1.24	0.85	2238.	1.92	1.18	40400.	2.60	1.47	4986.
0.58	0.47	84855.	1.26	0.86	1043.	1.94	1.19	69610.	2.62	1.47	4617.
0.60	0.48	84364.	1.28	0.88	5107.	1.96	1.20	88475.	2.64	1.48	1986.
0.62	0.49	82474.	1.30	0.89	9141.	1.98	1.21	120702.	2.66	1.49	1639.
0.64	0.51	79283.	1.32	0.90	11851.	2.00	1.22	146512.	2.68	1.50	1033.
0.66	0.52	74626.	1.34	0.91	13648.	2.02	1.23	170010.	2.70	1.50	7096.
0.68	0.53	68452.	1.36	0.92	14352.	2.04	1.23	145411.	2.72	1.51	7301.
0.70	0.54	61103.	1.38	0.93	14343.	2.06	1.24	154811.	2.74	1.52	6850.
0.72	0.56	53428.	1.40	0.94	13185.	2.08	1.25	32725.	2.76	1.53	5348.
0.74	0.57	45382.	1.42	0.95	10148.	2.10	1.26	63616.	2.78	1.53	6667.
0.76	0.58	35239.	1.44	0.96	6838.	2.12	1.27	92040.	2.80	1.54	7912.
0.78	0.59	25905.	1.46	0.97	1700.	2.14	1.28	98422.	2.82	1.55	8849.
0.80	0.61	17193.	1.48	0.98	4885.	2.16	1.29	93334.	2.84	1.56	10064.
0.82	0.62	9836.	1.50	0.99	9931.	2.18	1.29	81681.	2.86	1.56	12326.
0.84	0.63	6554.	1.52	1.00	15076.	2.20	1.30	76199.	2.88	1.57	12863.
0.86	0.64	7970.	1.54	1.01	18792.	2.22	1.31	42501.	2.90	1.58	19524.
0.88	0.65	11610.	1.56	1.02	21154.	2.24	1.32	11507.	2.92	1.59	19941.
0.90	0.67	15312.	1.58	1.02	25156.	2.26	1.33	3897.	2.94	1.59	20803.
0.92	0.68	18594.	1.60	1.03	23577.	2.28	1.34	9968.	2.96	1.60	18690.
0.94	0.69	18417.	1.62	1.04	19458.	2.30	1.34	19475.	2.98	1.61	19108.
0.96	0.70	16894.	1.64	1.05	13636.	2.32	1.35	25297.	3.00	1.62	16451.

M/V STEWART J. CORT

TRANSFER FUNCTION

DRAFT FWD = 18FT 0IN

AFT = 21FT 3IN

SHIP SPEED = 11.6 MPH

HEADING ANGLE = 0.°

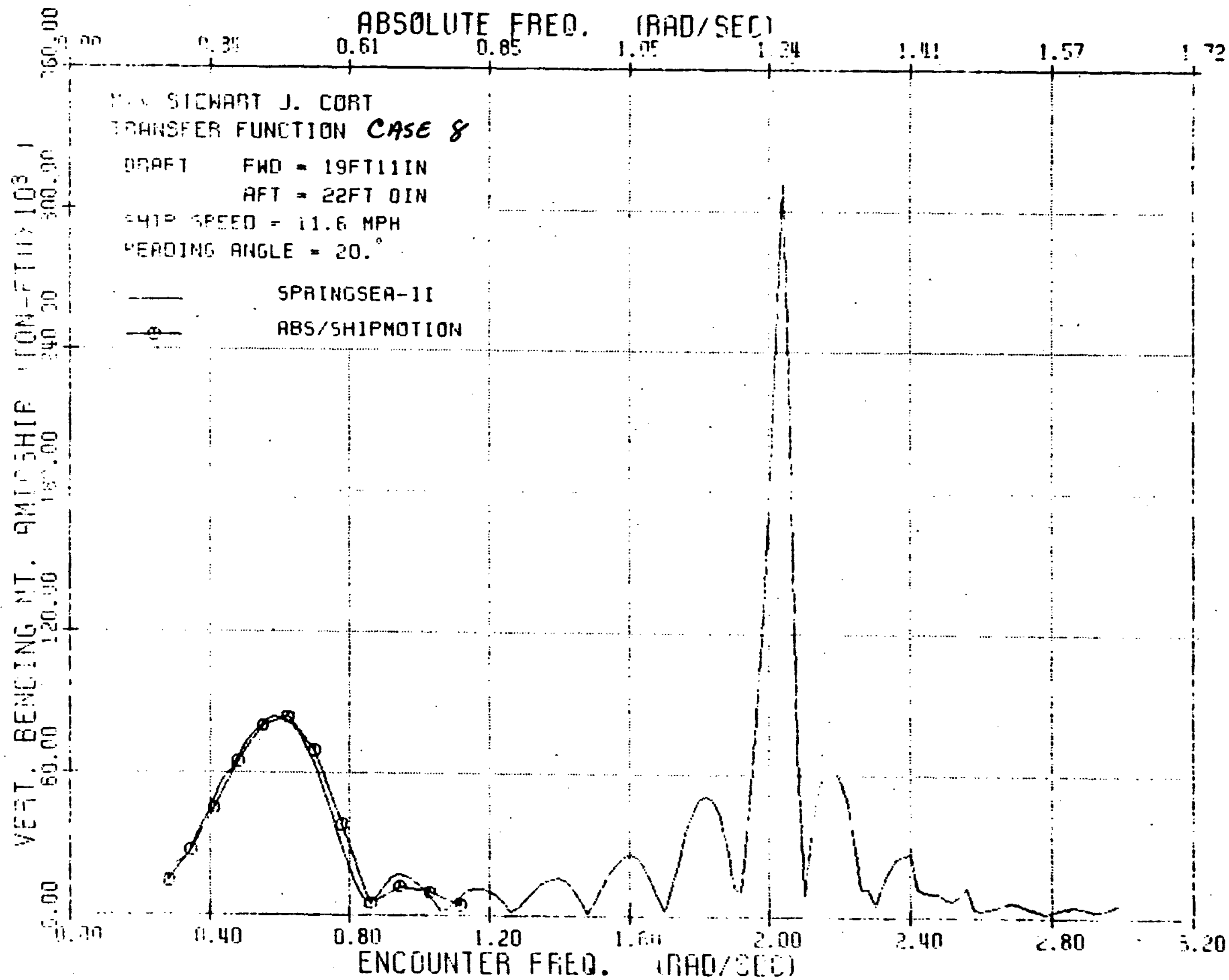
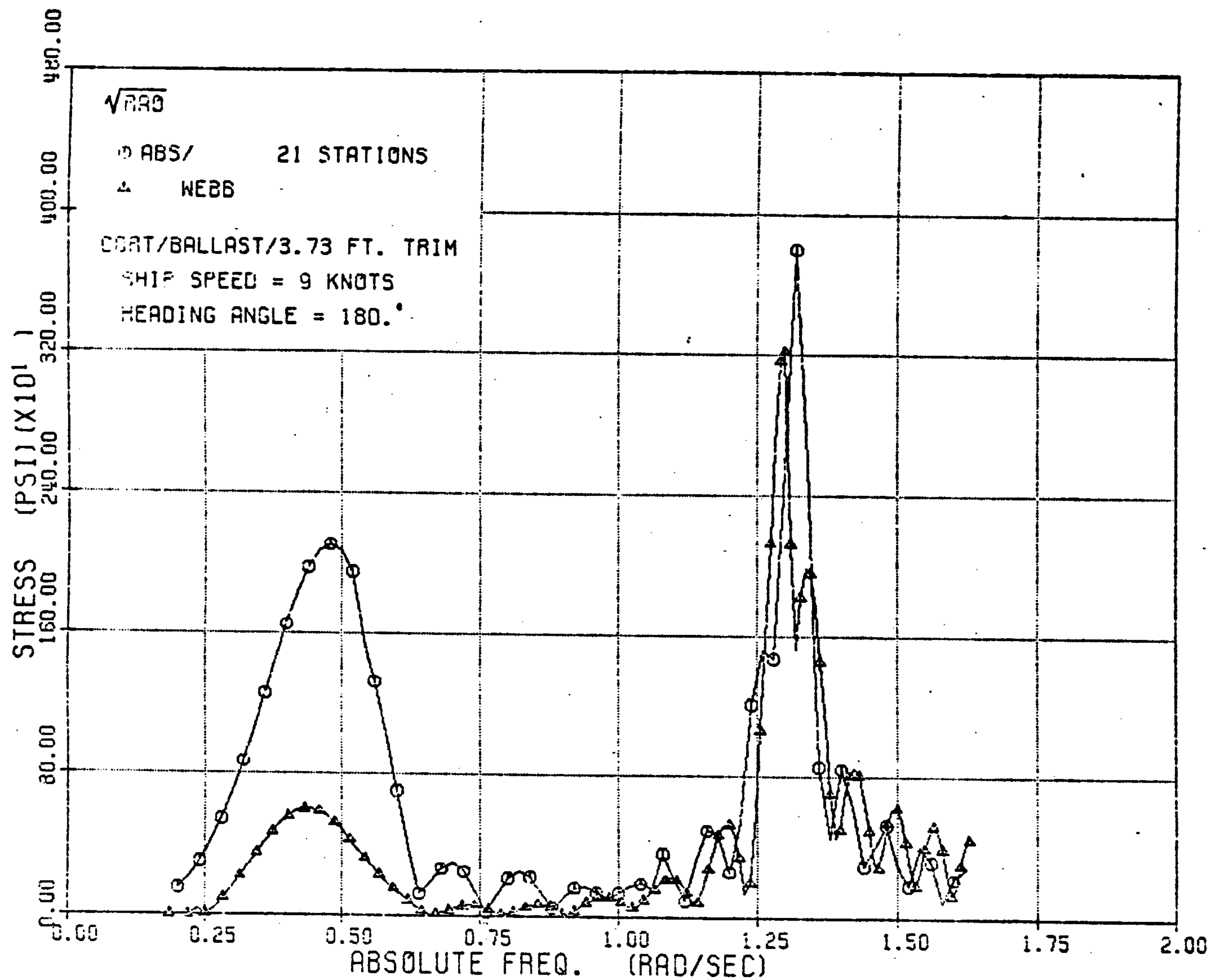

ABSOLUTE FREQ. (RAD/SEC)
0.61
0.85
1.57
STEWART J. CORT
TRANSFER FUNCTION CASE 8
DRAFT FWD = 19FT11IN
AFT = 22FT 0IN
SHIP SPEED = 11.6 MPH
HEADING ANGLE = 20.°
SPRINGSEA-II
ABS/SHIPMOTION
VERT. BENDING MT. AMIDSHIP (TON-FT)×10³
60.00
120.00
240.00
300.00
0.40
0.80
1.20
2.00
2.40
2.80
ENCOUNTER FREQ. (RAD/SEC)

Fig. 8

ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)	ω_e (RAD/SEC)	ω (RAD/SEC)	M_v (TON-FT)
0.30	0.27	21837.	0.98	0.72	14998.	1.65	1.08	15709.	2.34	1.39	20327.
0.32	0.28	23290.	[illegible]	[illegible]	[illegible]	1.68	1.09	7640.	2.36	1.39	25039.
0.34	0.30	26645.	1.02	[illegible]	[illegible]	1.70	1.10	2376.	2.38	1.40	26611.
0.36	0.31	32829.	1.04	0.76	5842.	1.72	1.11	11898.	2.40	1.41	26807.
0.38	0.33	38984.	1.06	0.77	2026.	1.74	1.12	22415.	2.42	1.42	11895.
0.40	0.34	45687.	1.08	0.78	2529.	1.76	1.13	35220.	2.44	1.43	10707.
0.42	0.36	52418.	1.10	0.79	5948.	1.78	1.14	43439.	2.46	1.44	10297.
0.44	0.37	58156.	1.12	0.80	8627.	1.80	1.15	49044.	2.48	1.44	9912.
0.46	0.39	61117.	1.14	0.81	10544.	1.82	1.16	51204.	2.50	1.45	8095.
0.48	0.40	66774.	1.16	0.82	11471.	1.84	1.17	49206.	2.52	1.46	7114.
0.50	0.41	72015.	1.18	0.83	11465.	1.86	1.17	42415.	2.54	1.47	9225.
0.52	0.43	76310.	1.20	[illegible]	10474.	1.88	1.18	30347.	2.56	1.48	12559.
0.54	0.44	79444.	1.22	0.86	8512.	1.90	1.19	12690.	2.58	1.48	3456.
0.56	0.46	82465.	1.24	0.87	5692.	1.92	1.20	9924.	2.60	1.49	2843.
0.58	0.47	84112.	1.26	0.88	1980.	1.94	1.21	41082.	2.62	1.50	3577.
0.60	0.48	83648.	1.28	0.89	2825.	1.96	1.22	76189.	2.64	1.51	4170.
0.62	0.50	82345.	1.30	0.90	6512.	1.98	1.23	118428.	2.66	1.52	5660.
0.64	0.51	79685.	1.32	0.91	9851.	2.00	1.24	172453.	2.68	1.52	6342.
0.66	0.52	75577.	1.34	0.92	12590.	2.02	1.25	246685.	2.70	1.53	6038.
0.68	0.54	70157.	1.36	0.73	15019.	2.04	1.26	311258.	2.72	1.54	4936.
0.70	0.55	63429.	1.38	0.94	15805.	2.06	1.26	206877.	2.74	1.55	3629.
0.72	0.56	55561.	1.40	0.95	16415.	2.08	1.27	70051.	2.76	1.56	3153.
0.74	0.58	46807.	1.42	0.96	14571.	2.10	1.28	9900.	2.78	1.56	1640.
0.76	0.59	37880.	1.44	0.97	10956.	2.12	1.29	34198.	2.80	1.57	2328.
0.78	0.60	28873.	1.46	0.98	6108.	2.14	1.30	54063.	2.82	1.58	3499.
0.80	0.61	20288.	1.48	0.99	933.	2.16	1.31	62893.	2.84	1.59	4023.
0.82	0.63	12801.	1.50	1.00	6195.	2.18	1.32	63351.	2.86	1.60	4560.
0.84	0.64	7172.	1.52	1.01	11995.	2.20	1.33	58018.	2.88	1.60	4221.
0.86	0.65	5675.	1.54	1.02	17331.	2.22	1.33	50687.	2.90	1.61	3312.
0.88	0.66	8283.	1.56	1.03	21740.	2.24	1.34	32966.	2.92	1.62	2997.
0.90	0.67	12166.	1.58	1.04	24629.	2.26	1.35	12105.	2.94	1.63	3273.
0.92	0.69	16218.	1.60	1.05	26330.	2.28	1.36	11804.	2.96	1.63	4176.
0.94	0.70	17347.	1.62	1.06	25458.	2.30	1.37	4590.	2.98	1.64	5104.
0.96	0.71	16644.	1.64	1.07	21809.	2.32	1.38	13224.	3.00	1.65	5732.

M/V STEWART J. CORT
TRANSFER FUNCTION

DRAFT FWD = 19FT11IN
AFT = 22FT 0IN
SHIP SPEED = 11.6 MPH
HEADING ANGLE = 20.°



√RAO
ABS/ 21 STATIONS
WEBB
CORT/BALLAST/3.73 FT. TRIM
SHIP SPEED = 9 KNOTS
HEADING ANGLE = 180.°
STRESS (PSI)(X10[1])
0.00
80.00
160.00
240.00
320.00
400.00
480.00
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
ABSOLUTE FREQ. (RAD/SEC)

Fig. 9

Part C

Update - Revised vertical bending moments amidships for the original 8 conditions listed in Table 2 of main report
January 1981

American Bureau of Shipping
Sixty-five Broadway
New York, N. Y. 10006

Refer to: DL/YNC/ml
File Ref: RD-1

7 April 1981

Captain H.M. Veillette
Chief, Marine Technology Division
United States Coast Guard
2100 Second Street, S.W.
Washington, DC 20593

Dear Captain Veillette:

With reference to our letter dated 17 March 1981, we have now completed the technical report entitled "Evaluation of Analytical Methods for Predicting Hull Girder Dynamic Responses in Waves", Report No. OE-81001 by Y.N. Chen and J.W. Chiou. We are now forwarding this report to you in the enclosure. The revised transfer functions corresponding to the eight cases selected from the Coast Guard's full scale stress and wave measurement program are contained in Appendix B. In addition, comparisons have been made in this report between our approach and the formulation of Goodman which has been programed for the Coast Guard by Webb Institute. We would like to thank you again for making the latter computer program available to us.

We hope this report would provide interesting reading. Meanwhile, we are looking forward to receiving the draft of the DTNSRDC report and/or its appendix as mentioned in our 17 March letter.

Very truly yours,

AMERICAN BUREAU OF SHIPPING

Stanley G. Stiansen
Vice President

By: Donald Liu
Donald Liu
Chief Research Engineer

Encl:

TELEPHONE: 212-440-0300 CABLE ADDRESS "RECORD" TWX: 710-581-3089 TELEX: ITT 421966 RCA 232099 WUI 620353

The following pages are excerpts
from Technical Report below

AMERICAN BUREAU OF SHIPPING
OCEAN ENGINEERING DIVISION

TECHNICAL REPORT

OE-81001

EVALUATION OF ANALYTICAL METHODS
FOR
PREDICTING HULL GIRDER DYNAMIC RESPONSES IN WAVES

BY

Y. N. CHEN

J. W. CHIOU

JANUARY 1981

Revised March 1981

AMERICAN BUREAU OF SHIPPING

ABSTRACT

A step-by-step synthesis of the analysis for the dynamic response of the hull girder to wave excitation based on various formulations is presented. Aspects examined in the present work include those for the determination of wave exciting forces, for the analysis of vibratory motion, of the damping prediction, and those for the long-term prediction in the realm of longitudinal strength evaluation. Sources of discrepancy among analytical methods are identified through quantitative comparison. They are also compared with results deduced from full scale measured data. The latter is analyzed by the application of the modified "partial spectrum" method for damping evaluation and by the Ochi long-term method for extreme value extrapolation.

(page 1)

I INTRODUCTION

A major consideration in the evaluation of a ship's longitudinal strength is the dynamic response of its hull girder under the influence of wave action. In this connection, the capability of the hull girder is primarily measured by the combined effect of three bending moment components, namely, the bending moment induced by the direct action of the waves, the bending moment induced by the rigid body motion of the ship, and the bending moment attributed to the dynamic amplification of the hull structure's vibratory motions.

(page 3)

It is interesting to note that the Coast Guard has undertaken a full scale wave and stress measurement project during the 1979-80 season onboard of the Great Lakes bulk carrier Stewart J. Cort which results in producing a number of transfer functions (RAO) of bending moment. Preliminary comparison indicates that the calculated results of SPRINGSEA-II compare somewhat more favorably than the first method. Nevertheless, such comparisons are not conclusive. Limited comparison between analytical results obtained from the aforementioned computer programs indicates that the discrepancy near the springing peak of the transfer function may differ by a factor of 2 or higher. Although this observation is by no means conclusive, the large difference in itself is a manifestation of how unsettled springing analysis remains.

In dealing with the synthesis of analytical determination of the vibratory motions, a simplified method, based upon the classical Hamilton variational principle is developed. This method, on account of its simplicity, offers the possibility of investigating the step-by-step excursion of the two basic methods of References [1, 2, 3], and Ref. [4].

In a way, the present energy method serves as a tracing mechanism. In order to separate the issues of wave force calculation and methods of vibration analysis, the computer program for the energy method is designed to accept wave-induced forces as input information but the motion (rigid body) induced force is determined within the program. Other than this aspect, the energy method can also stand on its own as a complete method for the determination of the transfer function, valid throughout the entire frequency range provided that the wave-induced force is valid in such a range.

The present energy method has been used to calculate transfer functions of bending moment of the Stewart J. Cort for eight loading conditions in conjunction with the aforementioned stress measurement project undertaken by the Coast Guard.

VIII CONCLUSION

A step-by-step synthesis of the analysis for the dynamic response of the hull girder to wave excitation in the context of longitudinal strength has been presented in the preceding sections. The Great Lakes bulk carrier M/V Stewart J. Cort has been selected as an illustrative example. Through the comparison of results at various stages, the following conclusion can be drawn.

1. The discrepancy in the computation of transfer function (or RAO) is traced to, primarily, the method employed in the calculation of wave-induced forces. As for which of these methods is more preferable, it appears that the method of Salvesen et. al employed in Ref. [13] should be used by inference to the comparison of long term results. Other methods for computing the wave-induced forces are valid in the low frequency range but the corresponding wave excitation is judged too high in the high frequency range.

APPENDIX B

The present energy method has been utilized to compute transfer functions for comparison with the USCG wave and stress measurement project mentioned earlier. To ~~the~~ this purpose, the theoretical transfer functions corresponding to the following eight cases have been obtained.

		DRAFT			
Condition	Speed (MPH)	FWD	MID	AFT	Ship-Wave Angle (Degrees)
1	14.4	19'11"	20'7"	22'0"	6
2	14.4	19'11"	20'7"	22'0"	11
3	14.7	27'0"	27'0"	27'0"	6
4	14.2	27'0"	27'0"	27'0"	9
5	13.5	27'0"	27'0"	27'0"	23
6	13.5	27'0"	27'0"	27'0"	10
7	11.6	18'0"	19'11"	21'3"	0
8	11.6	19'11"	20'7"	22'0"	20

The resulting transfer functions of vertical bending moment amidship are tabulated below and they are displayed in Figs. B-1 to B-8.

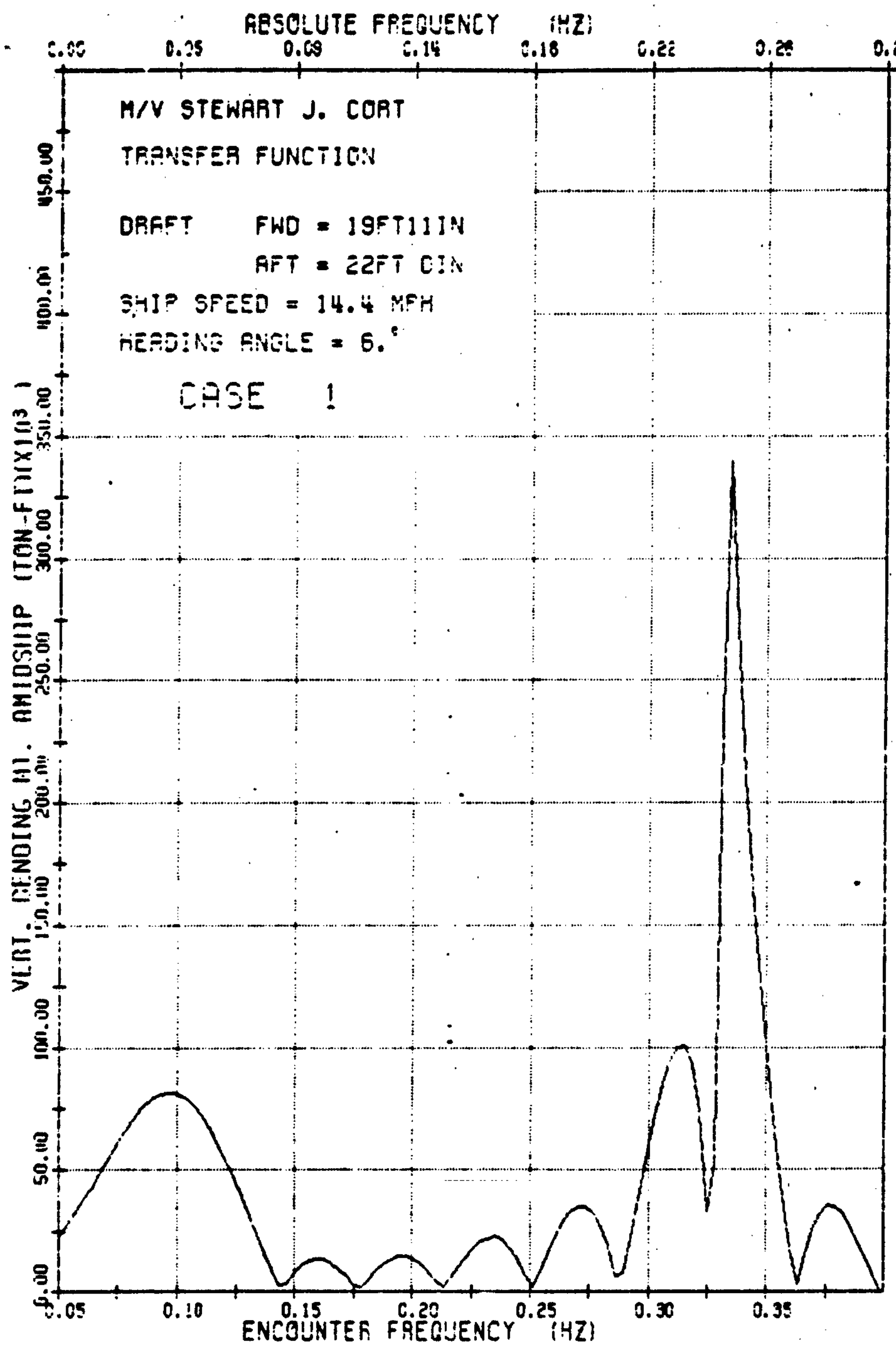


Fig. B1 - Transfer Function, Case 1

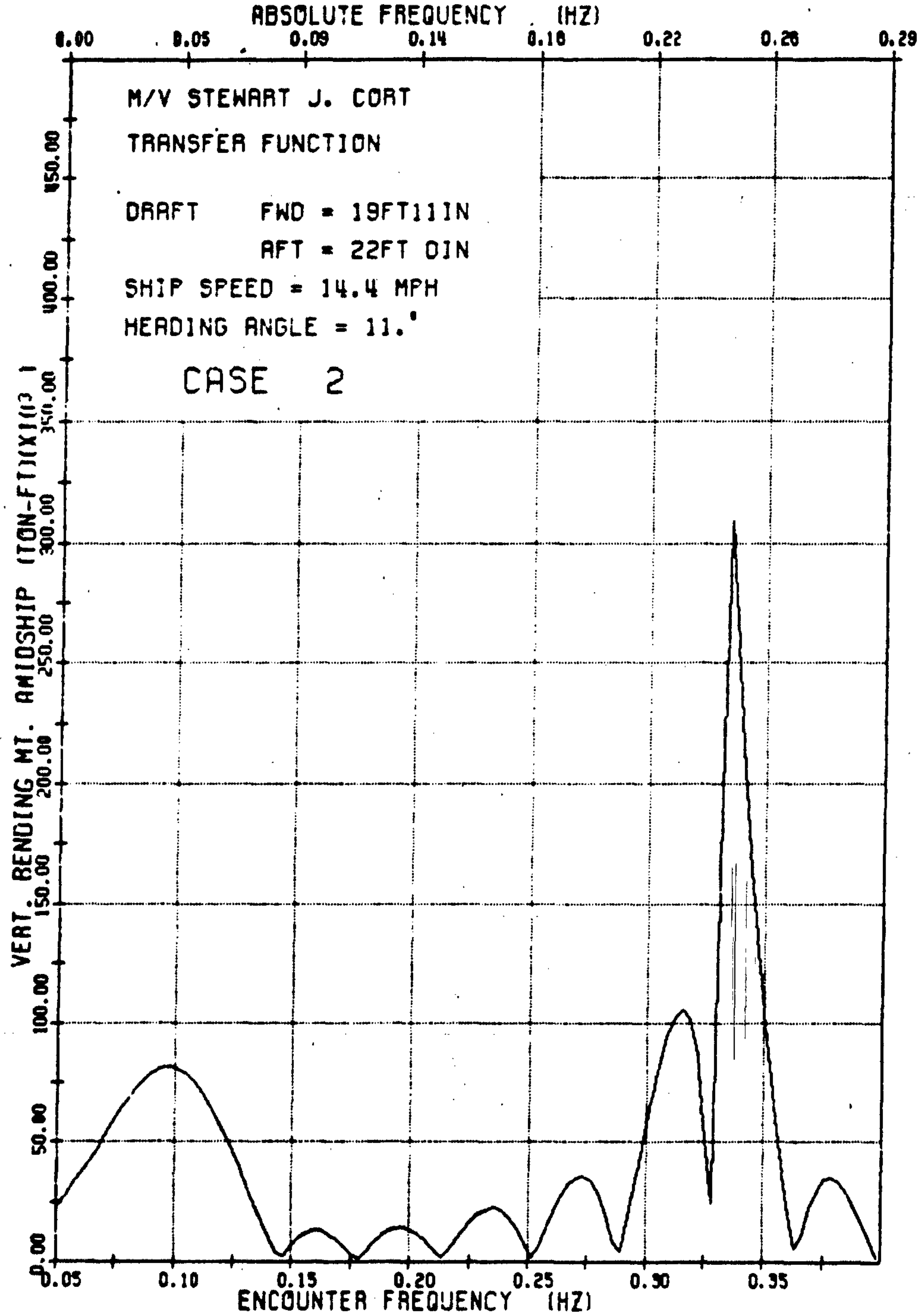


Fig. B2 - Transfer function, Case 2

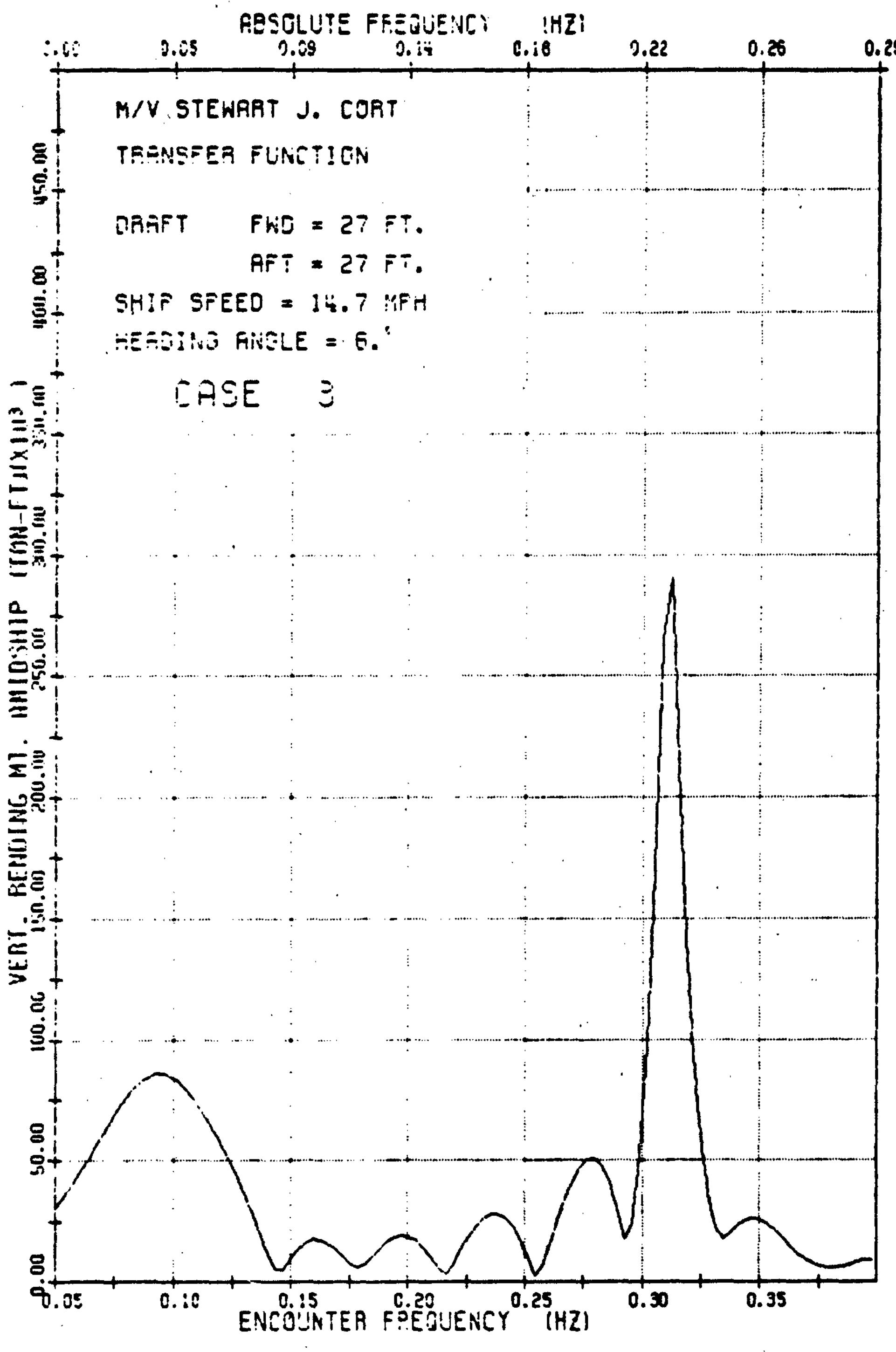


Fig. B3 - Transfer function, Case 3

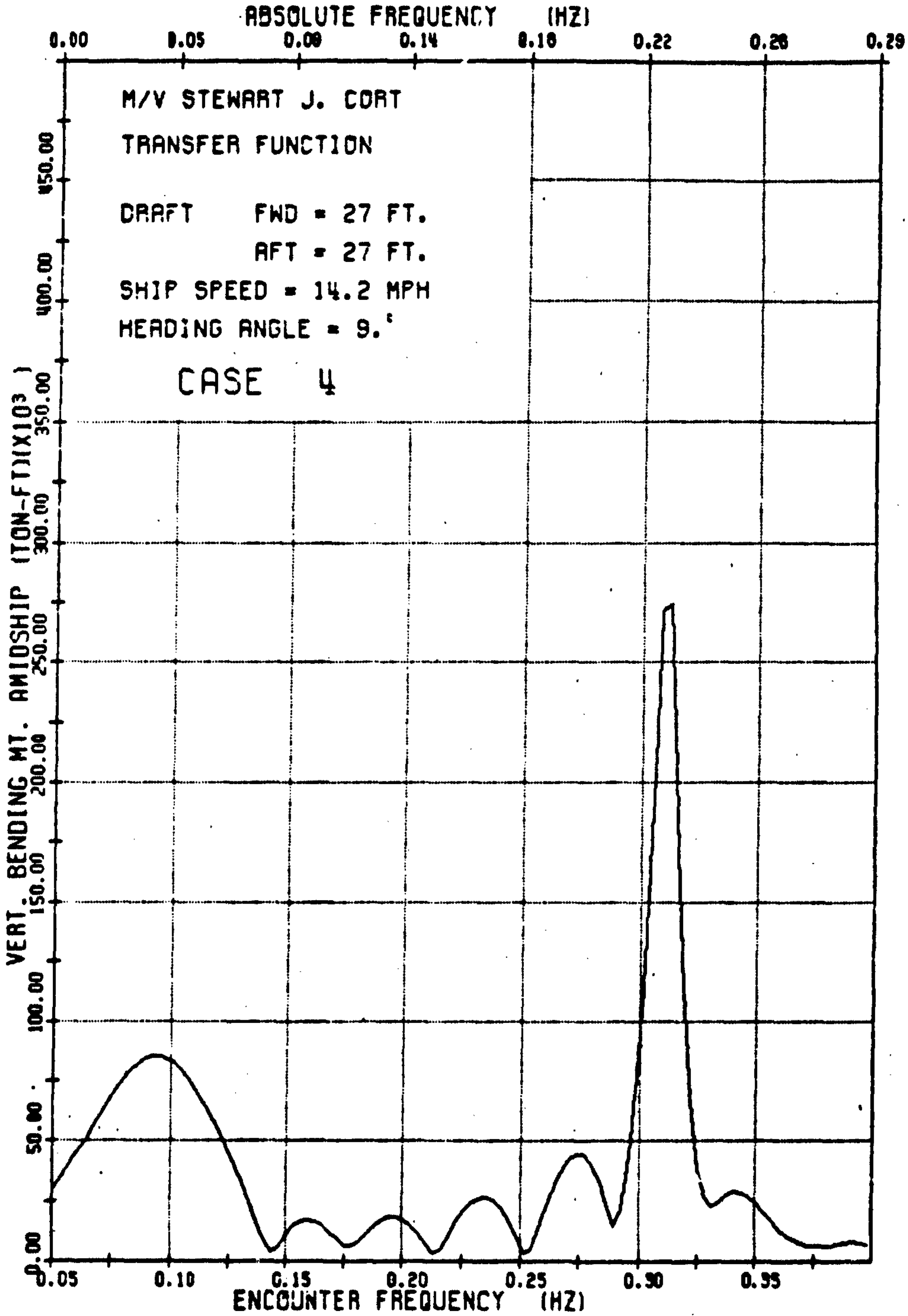


Fig. B4 - Transfer function, Case 4

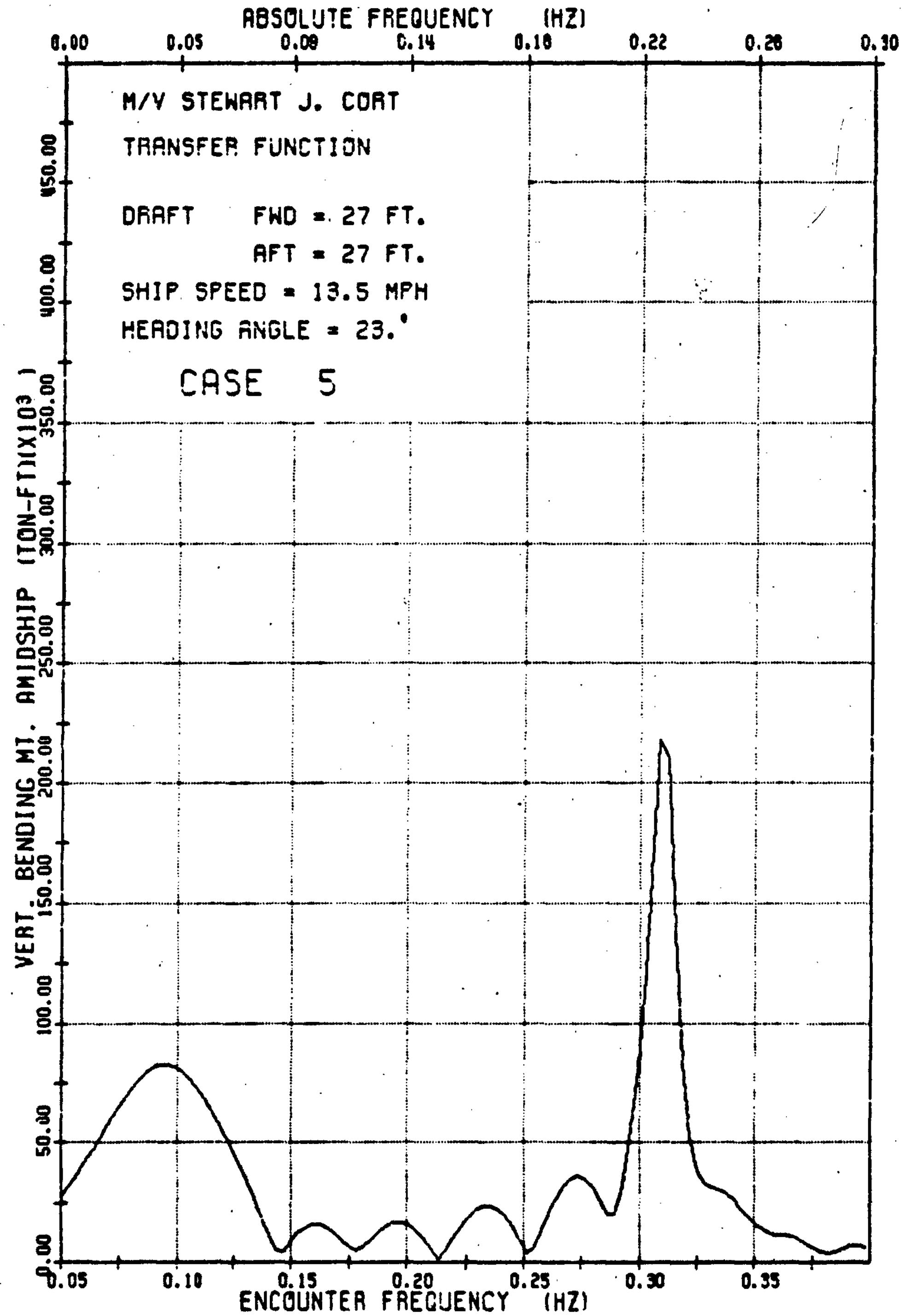


Fig. B5 - Transfer function, Case 5

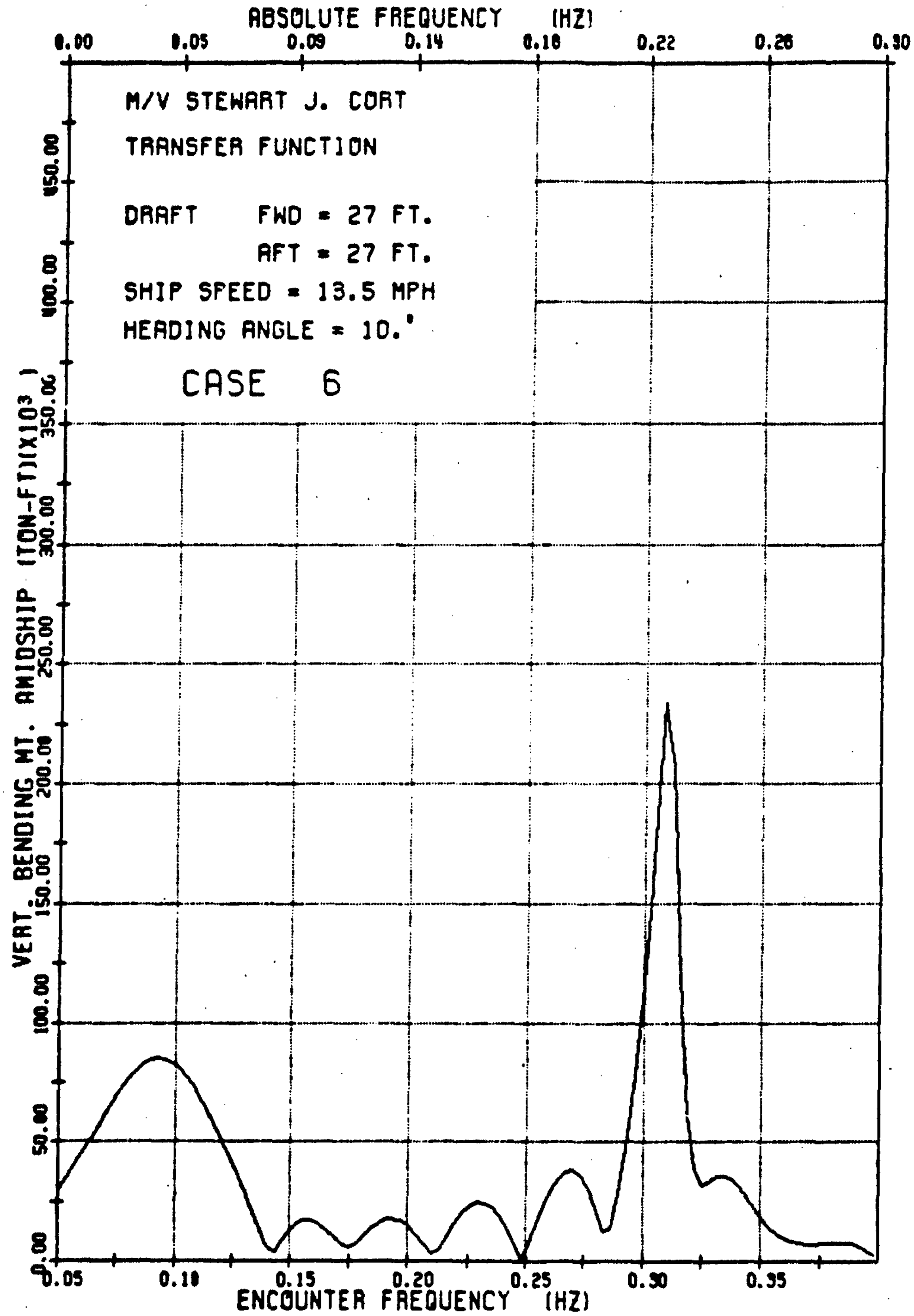


Fig. B6 - Transfer function, Case 6

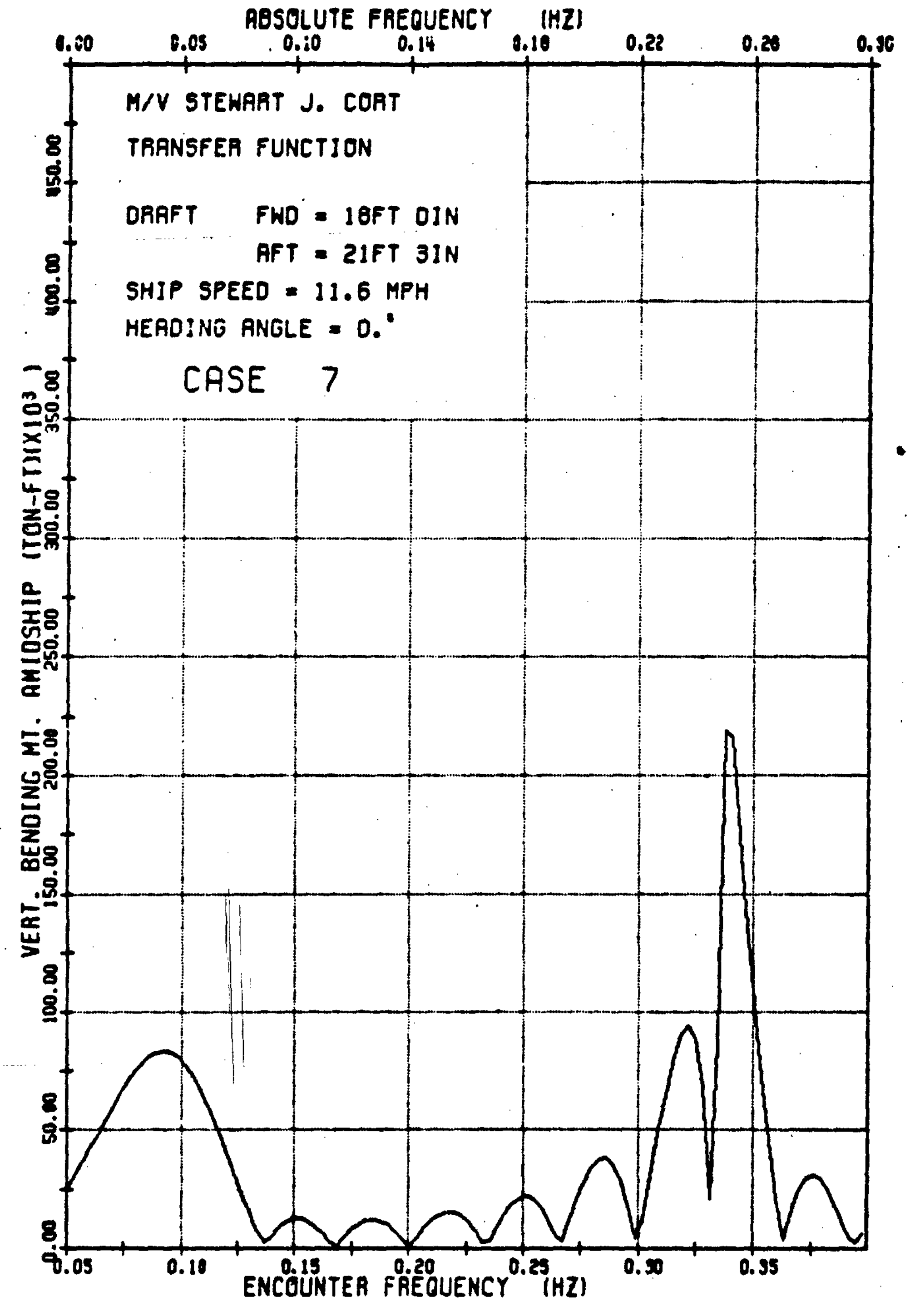


Fig. B7 - Transfer function Case 7

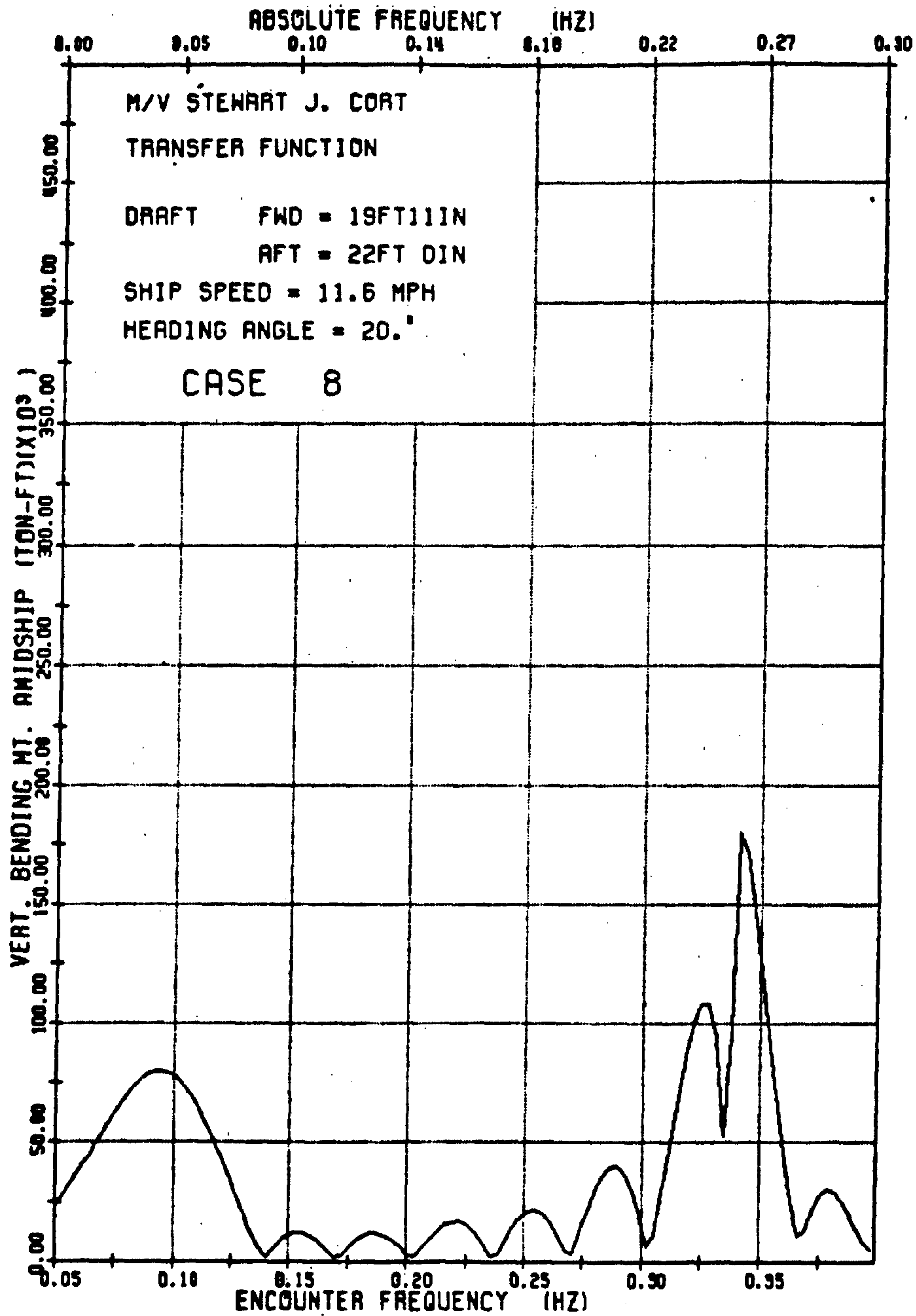


Fig. B8 - Transfer function, Case 8

CASE 1

ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)
0.051	23683.	0.143	2844.	0.236	22629.	0.328	53010.
0.054	27993.	0.146	3142.	0.239	20767.	0.331	233561.
0.057	32639.	0.150	7434.	0.242	17367.	0.334	339591.
0.060	37562.	0.153	10668.	0.245	12566.	0.337	272270.
0.064	42693.	0.156	12677.	0.248	6590.	0.341	211041.
0.067	47948.	0.159	13448.	0.251	1619.	0.344	164830.
0.070	53328.	0.162	13057.	0.255	8157.	0.347	126921.
0.073	58489.	0.166	11569.	0.258	15576.	0.350	94112.
0.076	63477.	0.169	9172.	0.261	22890.	0.353	65029.
0.080	68122.	0.172	6100.	0.264	28621.	0.357	39572.
0.083	72330.	0.175	2695.	0.267	32823.	0.360	17821.
0.086	75894.	0.178	1967.	0.271	35072.	0.363	3001.
0.089	78641.	0.181	5370.	0.274	34979.	0.366	15023.
0.092	80538.	0.185	8850.	0.277	32321.	0.369	25299.
0.095	81488.	0.188	11488.	0.280	26949.	0.372	31887.
0.099	81394.	0.191	13377.	0.283	18912.	0.376	35428.
0.102	80239.	0.194	14355.	0.286	6463.	0.379	35232.
0.105	77997.	0.197	14317.	0.290	7862.	0.382	32379.
0.108	74695.	0.201	13230.	0.293	22404.	0.385	27519.
0.111	70404.	0.204	11134.	0.296	38012.	0.388	21265.
0.115	65240.	0.207	8207.	0.299	53880.	0.392	14334.
0.118	59284.	0.210	4720.	0.302	69056.	0.395	7394.
0.121	52767.	0.213	1844.	0.306	82517.	0.398	612.
0.124	45777.	0.216	5874.	0.309	93110.	0.401	5051.
0.127	38462.	0.220	10218.	0.312	99553.	0.404	8566.
0.131	30919.	0.223	14234.	0.315	100227.	0.407	10779.
0.134	23377.	0.226	17558.	0.318	92813.	0.411	12177.
0.137	16016.	0.229	20741.	0.321	73324.	0.414	12995.
0.140	9044.	0.232	21845.	0.325	32756.	0.417	13897.

CASE 2

ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)
0.051	23285.	0.143	3767.	0.236	22966.	0.328	25070.
0.054	27531.	0.146	2339.	0.239	21435.	0.331	192857.
0.057	32114.	0.150	6692.	0.242	18352.	0.334	308963.
0.060	36976.	0.153	10083.	0.245	13827.	0.337	258079.
0.064	42049.	0.156	12272.	0.248	8045.	0.341	205617.
0.067	47254.	0.159	13235.	0.251	1816.	0.344	164280.
0.070	52593.	0.162	13038.	0.255	6508.	0.347	129313.
0.073	57724.	0.166	11733.	0.258	13982.	0.350	98345.
0.076	62696.	0.169	9499.	0.261	21162.	0.353	70254.
0.080	67342.	0.172	6554.	0.264	27609.	0.357	45187.
0.083	71571.	0.175	3193.	0.267	32252.	0.360	23355.
0.086	75152.	0.178	1538.	0.271	35041.	0.363	5844.
0.089	77991.	0.181	4753.	0.274	35559.	0.366	11012.
0.092	79971.	0.185	8297.	0.277	33541.	0.369	21986.
0.095	81024.	0.188	11013.	0.280	28781.	0.372	29525.
0.099	81051.	0.191	13023.	0.283	19833.	0.376	34061.
0.102	80032.	0.194	14154.	0.286	8297.	0.379	34836.
0.105	77939.	0.197	14290.	0.290	4353.	0.382	32846.
0.108	74794.	0.201	13384.	0.293	18771.	0.385	28688.
0.111	70663.	0.204	11462.	0.296	34605.	0.388	22939.
0.115	65656.	0.207	8686.	0.299	50985.	0.392	16311.
0.118	59850.	0.210	5351.	0.302	67002.	0.395	9456.
0.121	53470.	0.213	1627.	0.306	81676.	0.398	2018.
0.124	46601.	0.216	5097.	0.309	93887.	0.401	3438.
0.127	39388.	0.220	9464.	0.312	102404.	0.404	7367.
0.131	31925.	0.223	13583.	0.315	105679.	0.407	10085.
0.134	24432.	0.226	17075.	0.318	101539.	0.411	11872.
0.137	17084.	0.229	20485.	0.321	86312.	0.414	12660.
0.140	10084.	0.232	21869.	0.325	51737.	0.417	13782.

CASE 3

ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)
0.051	31036.	0.143	5063.	0.236	27769.	0.328	36462.
0.054	35350.	0.146	4966.	0.239	27815.	0.331	22029.
0.057	40021.	0.150	5544.	0.242	26101.	0.334	17807.
0.060	45004.	0.153	13507.	0.245	22584.	0.337	20182.
0.064	50377.	0.156	16186.	0.248	17341.	0.341	23346.
0.067	55697.	0.159	17464.	0.251	10555.	0.344	25608.
0.070	60995.	0.162	17347.	0.255	2542.	0.347	26349.
0.073	66188.	0.166	16031.	0.258	6488.	0.350	25637.
0.076	71037.	0.169	13714.	0.261	15825.	0.353	23758.
0.080	75432.	0.172	10778.	0.264	25086.	0.357	21070.
0.083	79251.	0.175	7730.	0.267	33719.	0.360	17736.
0.086	82294.	0.178	6020.	0.271	41155.	0.363	14616.
0.089	84457.	0.181	7296.	0.274	46791.	0.366	11731.
0.092	85634.	0.185	10317.	0.277	50111.	0.369	9275.
0.095	85753.	0.188	13646.	0.280	50556.	0.372	7389.
0.099	84767.	0.191	16432.	0.283	47636.	0.376	6178.
0.102	82675.	0.194	18316.	0.286	40957.	0.379	5960.
0.105	79569.	0.197	19096.	0.290	30364.	0.382	5846.
0.108	75522.	0.201	18644.	0.293	17675.	0.385	6303.
0.111	70795.	0.204	17121.	0.296	23781.	0.388	7150.
0.115	65629.	0.207	13869.	0.299	52043.	0.392	8035.
0.118	60193.	0.210	10014.	0.302	97981.	0.395	8619.
0.121	54568.	0.213	5706.	0.306	168940.	0.398	8667.
0.124	48590.	0.216	3274.	0.309	264695.	0.401	8128.
0.127	42065.	0.220	7205.	0.312	290503.	0.404	7287.
0.131	34958.	0.223	13628.	0.315	213601.	0.407	5488.
0.134	27261.	0.226	18680.	0.318	142218.	0.411	5279.
0.137	19323.	0.229	22949.	0.321	93510.	0.414	6046.
0.140	11516.	0.232	26075.	0.325	59864.	0.417	8105.

CASE 4

ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)
0.051	30757.	0.143	3720.	0.236	26445.	0.328	26365.
0.054	35135.	0.146	6208.	0.239	25084.	0.331	22656.
0.057	39870.	0.150	10812.	0.242	21972.	0.334	24907.
0.060	44912.	0.153	14380.	0.245	17175.	0.337	27706.
0.064	50335.	0.156	16570.	0.248	10877.	0.341	29009.
0.067	55703.	0.159	17332.	0.251	3388.	0.344	28630.
0.070	61036.	0.162	16710.	0.255	5039.	0.347	26030.
0.073	66248.	0.166	14945.	0.258	13780.	0.350	24015.
0.076	71098.	0.169	12285.	0.261	22371.	0.353	20621.
0.080	75473.	0.172	9212.	0.264	30289.	0.357	17067.
0.083	79245.	0.175	6501.	0.267	36979.	0.360	13614.
0.086	82214.	0.178	4072.	0.271	41889.	0.363	10887.
0.089	84275.	0.181	6442.	0.274	44450.	0.366	8818.
0.092	85323.	0.185	11675.	0.277	44249.	0.369	7417.
0.095	85287.	0.188	14745.	0.280	40896.	0.372	6616.
0.099	84122.	0.191	17056.	0.283	34190.	0.376	6323.
0.102	81835.	0.194	18334.	0.286	24273.	0.379	6287.
0.105	78520.	0.197	18438.	0.290	14921.	0.382	6565.
0.108	74265.	0.201	17306.	0.293	21611.	0.385	7164.
0.111	69333.	0.204	14691.	0.296	44131.	0.388	7774.
0.115	63568.	0.207	11176.	0.299	76786.	0.392	8056.
0.118	58334.	0.210	7018.	0.302	123576.	0.395	7771.
0.121	52510.	0.213	3312.	0.306	189931.	0.398	6807.
0.124	46336.	0.216	5276.	0.309	271202.	0.401	5195.
0.127	39639.	0.220	10403.	0.312	274327.	0.404	3273.
0.131	32406.	0.223	16470.	0.315	185801.	0.407	1140.
0.134	24656.	0.226	20836.	0.318	112932.	0.411	6767.
0.137	16766.	0.229	24143.	0.321	66741.	0.414	9279.
0.140	9165.	0.232	26087.	0.325	38229.	0.417	11255.

CASE 5

ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)
0.051	28434.	0.143	4934.	0.236	23630.	0.328	32870.
0.054	32584.	0.146	4394.	0.239	22309.	0.331	31350.
0.057	37092.	0.150	8700.	0.242	19428.	0.334	30265.
0.060	41914.	0.153	12421.	0.245	15102.	0.337	28513.
0.064	47123.	0.156	14883.	0.248	9615.	0.341	25811.
0.067	52315.	0.159	15982.	0.251	4067.	0.344	22507.
0.070	57507.	0.162	15727.	0.255	6234.	0.347	19062.
0.073	62621.	0.166	14324.	0.258	13390.	0.350	15977.
0.076	67428.	0.169	11980.	0.261	20634.	0.353	13670.
0.080	71818.	0.172	9086.	0.264	26729.	0.357	12296.
0.083	75673.	0.175	6188.	0.267	31664.	0.360	11597.
0.086	78788.	0.178	4969.	0.271	34935.	0.363	11189.
0.089	81055.	0.181	6787.	0.274	36100.	0.366	10513.
0.092	82365.	0.185	9798.	0.277	34354.	0.369	9365.
0.095	82648.	0.188	12770.	0.280	30900.	0.372	7772.
0.099	81846.	0.191	15053.	0.283	25488.	0.376	5962.
0.102	79952.	0.194	16377.	0.286	20062.	0.379	4343.
0.105	77048.	0.197	16644.	0.290	20619.	0.382	3741.
0.108	73187.	0.201	15572.	0.293	31866.	0.385	4600.
0.111	68624.	0.204	13344.	0.296	51378.	0.388	5844.
0.115	63595.	0.207	10170.	0.299	75499.	0.392	6704.
0.118	58269.	0.210	5901.	0.302	110923.	0.395	6882.
0.121	52761.	0.213	1431.	0.306	160665.	0.398	6304.
0.124	46931.	0.216	4844.	0.309	218081.	0.401	5034.
0.127	40608.	0.220	9873.	0.312	211054.	0.404	3238.
0.131	33756.	0.223	14611.	0.315	138025.	0.407	1284.
0.134	26365.	0.226	18648.	0.318	83120.	0.411	3623.
0.137	18750.	0.229	21660.	0.321	52626.	0.414	5599.
0.140	11243.	0.232	23383.	0.325	38099.	0.417	7042.

CASE 6

ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)
0.051	30617.	0.143	3895.	0.236	22637.	0.328	33309.
0.054	35118.	0.146	8614.	0.239	19175.	0.331	35445.
0.057	39975.	0.150	12791.	0.242	14139.	0.334	35728.
0.060	45134.	0.153	15610.	0.245	7772.	0.337	34158.
0.064	50654.	0.156	16954.	0.248	492.	0.341	30991.
0.067	56110.	0.159	16853.	0.251	7522.	0.344	26890.
0.070	61508.	0.162	15422.	0.255	15518.	0.347	22408.
0.073	66753.	0.166	12980.	0.258	23065.	0.350	18041.
0.076	71602.	0.169	9892.	0.261	29590.	0.353	14203.
0.080	75930.	0.172	6940.	0.264	34582.	0.357	11200.
0.083	79607.	0.175	5678.	0.267	37539.	0.360	9315.
0.086	82431.	0.178	7498.	0.271	38013.	0.363	8156.
0.089	84293.	0.181	10676.	0.274	35627.	0.366	7505.
0.092	85092.	0.185	13761.	0.277	30335.	0.369	7190.
0.095	84760.	0.188	16189.	0.280	22258.	0.372	7157.
0.099	83259.	0.191	17601.	0.283	13007.	0.376	7362.
0.102	80607.	0.194	17832.	0.286	13472.	0.379	7330.
0.105	76905.	0.197	16843.	0.290	27727.	0.382	7726.
0.108	72270.	0.201	14365.	0.293	47395.	0.385	7854.
0.111	66969.	0.204	10859.	0.296	72166.	0.388	7446.
0.115	61248.	0.207	6787.	0.299	101436.	0.392	6382.
0.118	55271.	0.210	3230.	0.302	138312.	0.395	4689.
0.121	49107.	0.213	5281.	0.306	186185.	0.398	2570.
0.124	42607.	0.216	10218.	0.309	233694.	0.401	1234.
0.127	35626.	0.220	15966.	0.312	206077.	0.404	3115.
0.131	28195.	0.223	20021.	0.315	119202.	0.407	5724.
0.134	20378.	0.226	22958.	0.318	60987.	0.411	11585.
0.137	12608.	0.229	24489.	0.321	38465.	0.414	12350.
0.140	5540.	0.232	24415.	0.325	31539.	0.417	12202.

CASE 7

ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)
0.051	26161.	0.143	8600.	0.236	3169.	0.328	68743.
0.054	31286.	0.146	11153.	0.239	8830.	0.331	20986.
0.057	36736.	0.150	12430.	0.242	14332.	0.334	86762.
0.060	42431.	0.153	12453.	0.245	18440.	0.337	219261.
0.064	48240.	0.156	11278.	0.248	21118.	0.341	215856.
0.067	54053.	0.159	5049.	0.251	22015.	0.344	174894.
0.070	59645.	0.162	6042.	0.255	20920.	0.347	136772.
0.073	65360.	0.166	2526.	0.258	17756.	0.350	102777.
0.076	70242.	0.169	1239.	0.261	12644.	0.353	72091.
0.080	74638.	0.172	4942.	0.264	5813.	0.357	44814.
0.083	78274.	0.175	7981.	0.267	3303.	0.360	21242.
0.086	81022.	0.178	10340.	0.271	12621.	0.363	3873.
0.089	82645.	0.181	11815.	0.274	20915.	0.366	14395.
0.092	83121.	0.185	12269.	0.277	28418.	0.369	23918.
0.095	82383.	0.188	11620.	0.280	34204.	0.372	29390.
0.099	80365.	0.191	9915.	0.283	37557.	0.376	30951.
0.102	77070.	0.194	7279.	0.286	37889.	0.379	29191.
0.105	72566.	0.197	3953.	0.290	34754.	0.382	25151.
0.108	66925.	0.201	755.	0.293	27993.	0.385	18914.
0.111	60335.	0.204	4385.	0.296	17686.	0.388	11889.
0.115	52986.	0.207	8769.	0.299	4552.	0.392	5192.
0.118	45098.	0.210	11845.	0.302	12366.	0.395	2563.
0.121	36914.	0.213	14097.	0.306	30175.	0.398	6407.
0.124	28828.	0.216	15250.	0.309	47993.	0.401	9177.
0.127	21042.	0.220	15181.	0.312	64890.	0.404	10187.
0.131	13660.	0.223	14051.	0.315	79380.	0.407	4978.
0.134	7013.	0.226	11217.	0.318	89700.	0.411	5793.
0.137	2384.	0.229	7591.	0.321	93774.	0.414	5885.
0.140	4973.	0.232	2534.	0.325	88613.	0.417	430.

CASE 8

ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)	ENCOUNTER FREQUENCY (HZ)	BENDING MOMENT (TON-FT)
0.051	23950.	0.143	5628.	0.236	2566.	0.328	190870.
0.054	28457.	0.146	5180.	0.239	3588.	0.331	183839.
0.057	33304.	0.150	11438.	0.242	9464.	0.334	67939.
0.060	38424.	0.153	12398.	0.245	14897.	0.337	53515.
0.064	43732.	0.156	12081.	0.248	19411.	0.341	85963.
0.067	49130.	0.159	10611.	0.251	21997.	0.344	95407.
0.070	54603.	0.162	8204.	0.255	22770.	0.347	92674.
0.073	59802.	0.166	5074.	0.258	21517.	0.350	83215.
0.076	64724.	0.169	1637.	0.261	18131.	0.353	69102.
0.080	69191.	0.172	2397.	0.264	12623.	0.357	52716.
0.083	73094.	0.175	5816.	0.267	5300.	0.360	35947.
0.086	76186.	0.178	8819.	0.271	3547.	0.363	20356.
0.089	78324.	0.181	10911.	0.274	12969.	0.366	9072.
0.092	79460.	0.185	12077.	0.277	22419.	0.369	11410.
0.095	79488.	0.188	12172.	0.280	31041.	0.372	18956.
0.099	78343.	0.191	11188.	0.283	37987.	0.376	24195.
0.102	76023.	0.194	9193.	0.286	42372.	0.379	26161.
0.105	72535.	0.197	6350.	0.290	43484.	0.382	25408.
0.108	67959.	0.201	2862.	0.293	40752.	0.385	22347.
0.111	62415.	0.204	2389.	0.296	33778.	0.388	17692.
0.115	56069.	0.207	6256.	0.299	22472.	0.392	12286.
0.118	49073.	0.210	5579.	0.302	6973.	0.395	7289.
0.121	41720.	0.213	13118.	0.306	12648.	0.398	4771.
0.124	34132.	0.216	15918.	0.309	35358.	0.401	7041.
0.127	26513.	0.220	16948.	0.312	60495.	0.404	9414.
0.131	19008.	0.223	17405.	0.315	86701.	0.407	10679.
0.134	11894.	0.226	15590.	0.318	113623.	0.411	10668.
0.137	5440.	0.229	12363.	0.321	140659.	0.414	9672.
0.140	1672.	0.232	7890.	0.325	167153.	0.417	8028.

APPENDIX F

University of Michigan - (Armin Troesch)

"Theoretical Estimate of the RAO for the M/V STEWART J. CORT"

THE UNIVERSITY OF MICHIGAN
DEPARTMENT OF NAVAL ARCHITECTURE AND MARINE ENGINEERING
NA&ME BUILDING, NORTH CAMPUS
ANN ARBOR, MICHIGAN 48109
(313) 764-6470

October 31, 1980

Lt. Mark Noll
G-DMT/TP54
U.S. Coast Guard
Washington, D.C. 20590

Dear Mark:

Please find enclosed the brief description of my method of predicting the M/V SJ Cort response amplitude operator. The emphasis of the work is on verifying the form of the equation of motion, and the magnitude of the excitation. Both of these seem to be reasonably predicted by the approach shown. I am sorry that I could not get the results to you earlier.

If there are any questions, just ask. Also have a good trip this November.

Sincerely,

Armin

Armin Troesch

AT:ab

Theoretical Estimate of the RAO
for the M/V Stewart J. Cort

October 30, 1980

Prepared by A.W. Troesch, P.E.
Department of Naval Architecture
and Marine Engineering
The University of Michigan

Theoretical Estimate of the RAO for the M/V Stewart J Cort

Prepared by Armin W. Troesch, P.E.
University of Michigan

The purpose of this brief paper is to give a detailed description of how the results of the ABS/MARAD funded Springing Project can be used to predict the RAO for the midship bending moment of a Great Lakes bulk carrier. For the sake of brevity, only the case of resonant response in head seas will be considered. For the off-resonant frequencies, the method is essentially the same.

As described by Troesch (1980), there is little or no coupling between springing and the rigid body modes of motion of heave and pitch. Let us also assume that 1) there is little coupling with the higher mode shapes and 2) that some of the hydrodynamic aspects of full scale flexible ship can be approximated by the hinged model used in the experiments at the University of Michigan. The uncoupled differential equation describing the normalized springing response, q_2 , for the hinged ship is then given as

$$\ddot{q}_2(a_{22}+A_{22}) + \dot{q}_2(b_{22}+B_{22}) + q_2C_{22} = M_0(1+\ell_A/\ell_F) + E_2 \quad . \qquad (1)$$

For an explanation of the various coefficients see Troesch (1980). It is only important here to note that

$$M_0 = -k_s(1 + \ell_A/\ell_F)\, q_2 \qquad (2)$$

where M_0 is the midship bending moment and k_s is the internal spring constant.

Now define an internal spring constant, c_{22} , as

$$c_{22} = k_s(1 + \ell_A/\ell_F)^2 \quad ,$$

and also the damping ratio, ζ , as

$$\zeta = \frac{(b_{22}+B_{22})\omega_0}{2(c_{22}+C_{22})} = \frac{b_{22} + B_{22}}{2\sqrt{(c_{22}+C_{22})(a_{22}+A_{22})}}$$

where ω_0 is the natural frequency in springing.

By using the above definitions and equation (2), the solution for the springing response to sinusoidal excitation is

$$q_2 = \frac{E_2}{\omega_0^2(a_{22}+A_{22})} \left[\frac{1}{(1-\omega_e^2/\omega_0^2)+i2\zeta\omega_e/\omega_0}\right] . \tag{3}$$

Here i is used as an imaginary notation and equal to $\sqrt{-1}$. By manipulating the above expressions, the bending moment at midship can be shown to be

$$M_0 = \left[\frac{-E_2}{(1-\omega_e^2/\omega_0^2)+i2\zeta\omega_e/\omega_0}\right] \left[1 - \frac{C_{22}}{\omega_0^2(a_{22}+A_{22})}\right] \left[\frac{1}{1+\ell_A/\ell_F}\right] \tag{4}$$

Troesch (1980) contends that there is little hope of theoretically predicting the total springing damping, $(b_{22} + B_{22})$, and so emphérical information must be used. In this study, we will use full scale data to estimate both the damping ratio, ζ, and the natural frequency, ω_0. The other terms will be calculated or estimated from experiments.

If E_2 in equation (4) represents the excitation due to an incident wave of unit amplitude and frequency ω_e, then M_0 can be written as $M_0(\omega_e)$ the response amplitude operator (RAO) of the midship bending moment. At resonance (i.e. $\omega_e = \omega_0$), the total bending moment becomes

$$M_0 = \frac{-E_2}{(1+\ell_A/\ell_F)(i2\zeta)} \left[1 - \frac{C_{22}}{\omega_0^2(a_{22}+A_{22})}\right] . \tag{5}$$

If we knew the values of the various terms in equation (5), we could calculate the first order RAO. Noll (1980) gives a range of values for ζ and ω_0 for the SJ Cort in various loading conditions. Restricting our attention to the full load condition, the average values are the following:

$$\zeta_{ave} \cong .0154$$

and

$$\omega_{0_{ave}} \cong .303 \text{ hz.}$$

If the more recent data from the fall 1979 SJ Cort measurements are examined, the full load natural frequency for that set is close to $\omega_0 = .32$ hz. Both of these natural frequencies will be used in the calculations.

The ship length to wave length ratio for a given frequency of encounter and ship velocity can be found from the following expression:

$$L/\lambda = L(-\sqrt{g} + \sqrt{g + 8\pi U\omega_e})^2/8\pi U^2 \quad . \qquad (6).$$

In equation (6) the ship's length L, the gravitational constant g, and the forward velocity U must all be in consistent units. The frequency of encounter, ω_e, is in cycles per second, i.e. hz. Setting $\omega_e=\omega_0=.303$ hz or .32 hz and letting U take the values of 14.7 mph, 14.2 mph, and 13.5 mph the L/λ ratios at resonance can be calculated and are shown in Table 1.

Table 1 - L/λ Values for $\omega_e=\omega_0$

U (mph)	L/λ (ω_0=.303 hz)	L/λ (ω_0=.32 hz)
14.7	5.95	6.43
14.2	6.08	6.56
13.5	6.26	6.76

With these values for L/λ and Figure 11 in Troesch (1980), the magnitude of the first order excitation, E_2, for the model can be determined. The hydrostatic restoring coefficient C_{22} can easily be calculated and the model inertia and added mass, $a_{22}+A_{22}$, can be read from Figure 6 in Troesch (1980). Equation (5) then can be used to determine the magnitude of the first order transfer function, $M_0(\omega_0)$. Table 2 summarizes the calculations for the RAOs.

In relationship to Table 2, there are two points worth noting. First, the generalized excitation E_2 and normalized mass coefficient $a_{22}+A_{22}$ used in equation (5) are for a hinged ship, i.e. two rigid halves connected by a flexible spring at midships. This only approximates the full scale structural dynamics. And secondly, the damping term ζ is only an average. The actual range of values varied from .006 to .025, a decrease of 39% to an increase of 62%. Since M_2 is inversely proportional to ζ, it also can only be considered as an average.

If the RAO for other frequencies is desired, equation (4) can be used in a fashion similar to that already shown. Such calculations for the model were

Table 2 - Various RAO's for the SJ Cort at Resonance

ω_n = .303 hz

U (mph)	E_2 (model) (ft-lbs/ft)	M_2 (full scale) (ft-tons/ft)
14.7	93	169,200
14.2	37	67,300
13.5	58	106,000

ω_n = .32 hz

U (mph)	E_2 (model) (ft-lbs/ft)	M_2 (full scale) (ft-tons/ft)
14.7	130	237,000
14.2	148	269,000
13.5	128	235,000

done by Troesch (1980) and the results plotted in Figures 17 and 18 of that work. (A copy of Figure 18 is included here as an illustration.) See Troesch (1980) for details.

References

Noll, M.D. (1980). "Evaluation of SDRC Damping Analysis," CG-B-5-80, U.S. Coast Guard, Washington, DC.

Troesch, A.W. (1980). "Ship Springing - An Experimental and Theoretical Study," Dept. of Naval Architecture and Marine Engineering, The University of Michigan, Ann Arbor, Mich.

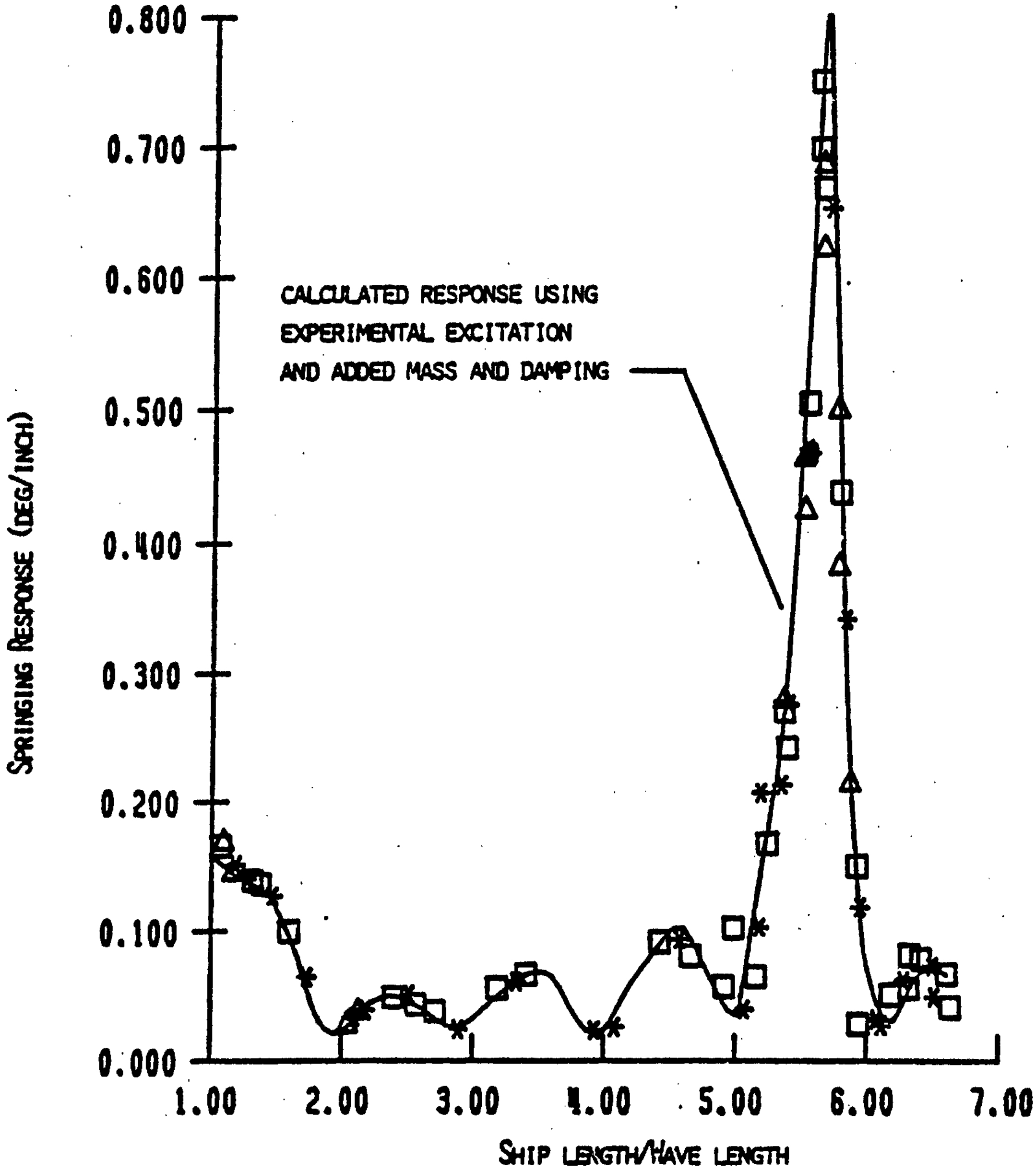


FIGURE 18: COMPARISON BETWEEN MEASURED RESPONSE AND PREDICTED RESPONSE
SPRING THICKNESS =.500 IN. MODEL VELOCITY ≃ 2.90 FT/SEC.

APPENDIX G

Webb Institute of Naval Architecture - (R. D. Sedat)

"Springing Calculations on the STEWART J. CORT Using Linear Theory"

CENTER FOR MARITIME STUDIES

WEBB INSTITUTE OF NAVAL ARCHITECTURE

CRESCENT BEACH ROAD GLEN COVE, NEW YORK 11542

January 19, 1981

SPRINGING CALCULATIONS ON THE STEWART J. CORT USING LINEAR THEORY

by R. D. Sedat

Springing is a wave induced vibration of a ship's hull which can contribute substantially in certain circumstances to the total bending moment. As prediction of these bending moments in the design stage is necessary to ensure adequate longitudinal strength, the U. S. Coast Guard undertook a comparison of measured bending moments on the STEWART J. CORT and those predicted by linear springing theory.

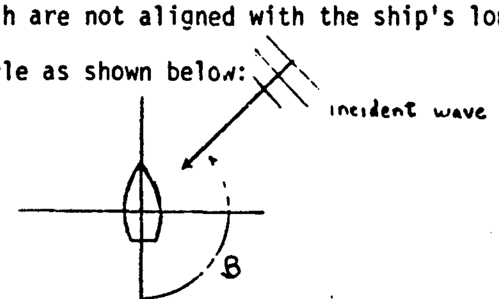
The Center for Maritime Studies (CMS) staff at Webb Institute of Naval Architecture has been working on the springing problem for some time. They have utilized as their starting point the basic linear springing theory proposed by Goodman (1). Hoffman and van Hooff modified this theory somewhat to take into account speed effects on added mass and damping. Zielinski then programmed their work for ease in making predictions. These modifications are thoroughly described, along with program documentation, in References (2, 3, 4 and 5), so they will not be reiterated here.

Under contract with the U. S. Coast Guard, Webb Institute of Naval Architecture was asked to apply this program to predict springing induced bending moment per foot of wave height for the STEWART J. CORT, a 998' Great Lakes ore carrier, under the following conditions:

Case No.	Speed (ft/sec)	Draft Fwd	Draft Mid	Draft Aft	Offset File	Heading °	W_n (rad/sec)
1	21.12	19'11"	20'7"	22'0"	ofcor 3	174	2.205
2	21.12	19'11"	20'7"	22'0"	ofcor 3	169	2.205
3	21.56	27'0"	27'0"	27'0"	ofcor 1	174	1.960
4	20.83	27'0"	27'0"	27'0"	ofcor 1	171	2.080
5	19.80	27'0"	27'0"	27'0"	ofcor 1	157	2.073
6	19.80	27'0"	27'0"	27'0"	ofcor 1	170	2.080
7	17.01	18'0"	19'11"	21'3"	ofcor 2	180	2.205
8	17.01	19'11"	20'7"	22'0"	ofcor 3	160	2.205

$$.2 > \omega_e > 2.5 \text{ rad/sec}$$

In order to calculate the springing response for these cases, Webb's original head seas program was changed to account for other headings. This principally involves a modification of certain terms in the exciting force equation for wave headings which are not aligned with the ship's longitudinal axis. Defining the heading angle as shown below:



$\omega_e = \omega + \frac{\omega^2}{g} u\,(-\cos\beta)$ and $\zeta = \bar{\zeta}\, e^{ikx(-\cos\beta)}$. It can then be shown, (see Appendix I for sample derivation), that the following equations from Report International Shipbuilding Progress, Vol. 23, June 1976 - No. 262, pp. 192 - 193 become

Original Equation	Updated
Equation 12(g)	(-cos β) * (Equation 12(g))
Equation 12(k)	(-cos β) * (Equation 12(k))
Equation 17(h)	(-cos β) * (Equation 17(h))
Equation 17(m)	(-cos β) * (Equation 17(m))

(Appendix I also contains a comparison of the original head sea program, SPM2G162, and the modified version, SPM2G163).

After modifying the computer program to include these changes, preliminary calculations were carried out for all 8 cases. The results of the full load predictions (Cases 3 - 6), plotted in Appendix III, are seen to be slightly high, but in reasonable agreement with the peak bending moments measured at resonance.

The preliminary results of the light load cases, however, were much higher than the measured results. Accordingly, the remaining project effort was directed towards explaining this discrepancy.

The offset files were available at forty stations spaced between perpendiculars. In the light load cases, however, the actual waterline was slightly shorter. Since this change was less than 1% LBP, the available offsets were used to avoid having to interpolate and fair new stations at the ends.

Sensitivity studies showed that bending moments were not overly sensitive to a precise calculation of the mode shape. Studies on heading effects, however, revealed that calculated bending moments could be twice as high at 160^{0} heading as at 180^{0}.

In several of the preliminary runs, the calculated speed dependent added mass and damping were of the wrong sign; i.e, overall damping should increase and added mass decrease with forward speed. The program actually carries out the integration of the local speed dependent sectional mass, $\frac{V}{\omega_r^2}\frac{\partial N'}{dx}$, and damping, $-V\frac{dm'}{dx}$ (where N' and m' are the sectional hydrodynamic damping and added mass, respectively). It can be easily shown, however, that if the added mass and damping at the bow are zero, then the integrals, $\int \frac{dN'}{dx}$ and $\int \frac{dm'}{dx}$ reduce to the values of N' and m' at the stern. The program, however, approximates the derivatives by a simplified difference method and the resultant numerical inaccuracy produces different answers. The program was, therefore, modified* so that the values of N' and m' at the stern are used for the integrals. This change improved the agreement between predicted and measured values slightly.** Thus, data files for the other light load cases were carefully checked and the program re-run.*** The results of these calculations (Cases 1, 2, 7 and 8) are shown in Appendix III.

Conclusions

1. Webb's computerization of linear springing theory produces generally satisfactory results for the STEWART J. CORT, at full load, operating in mild sea conditions.

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*I.e., lines 1631 and 1632 of the program listing in Appendix I were inserted.

**It can be seen, however, that the speed dependent terms are only a small fraction of the total mass and damping.

***Some errors were found in the interpolated added mass and damping values used in the first set of runs. The correction of these errors showed that calculated bending moments were also particularly sensitive to added damping.

2. The calculation of speed dependent added mass and damping was found to be in error and has been corrected. Though these terms do not have a large impact on the results, they show that the numerical techniques used by the program for evaluating integrals involving $\frac{dN'}{dx}$, $\frac{dm'}{dx}$ and $\frac{dX}{dx}$ are highly approximate. Since integrals of these types also occur in the calculation of the exciting force, there is a distinct likelihood this calculation too contains significant numerical errors.

3. Heading effects appear significant and should be included in linear springing theories.

4. Peak bending moments calculated by the Webb program for the light load cases are significantly too high in three cases out of four. The calculated exciting forces seem to be responsible for these high bending moments. The following possible explanations are advanced:

   a. Sensitivity studies have shown that results are quite sensitive to variations in the hydrodynamic damping at the ends. Added mass and damping in this study was determined by Frank Close-fit methods at 40 stations between perpendiculars. At light drafts, LWL is slightly different than LBP. To avoid interpolation of new stations, and recalculation of added mass and damping coefficients, the values calculated between LBP's were used.

   b. Offset files were also created for 40 stations along the LBP.

   c. Wall-sidedness about the waterline is assumed for the calculation of exciting force. This assumption is more unrealistic for light load than full, particularly at the ends of the ship.

d. Calculated exciting forces may be subject to numerical inaccuracy, as noted in Conclusion 2.

Reasons a and b can be eliminated by use of exact station locations. Reason d could be changed by using a cubic spline technique to evaluate more accurate derivatives. Reason c, however, cannot be changed without extensive modifications to the program. Thus, until these changes are effected, light load predictions by Webb's linear spring program should be regarded skeptically.

REFERENCES

1. Goodman, R. A., "Wave-Excited Main Hull Vibration in Large Tankers and Bulk Carriers," RINA, Transactions, 1971.

2. Hoffman, D. and van Hooff, R.W., "Experimental and Theoretical Evaluation of Springing on a Great Lakes Bulk Carrier," USCG Report No. CG-D-8-74, July 1973.

3. van Hooff, R.W., "Further Developments in the Theory of Springing Applied to a Great Lakes Bulk Carrier," U S.C.G. Contract No. DOT-CG-23, 027-A, April 17, 1974.

4. van Hooff, R.W., Fitzgerald, V.R. and Lewis, E.V., "Application of Springing Experiment and Theory to Design Standards for Great Lakes Bulk Carriers," USCG Report No. CG-D-164-75, June 1975.

5. Hoffman, D. and van Hooff, R.W., "Experimental and Theoretical Evaluation of Springing on a Great Lakes Bulk Carrier," International Shipbuilding Progress, Vol. 23, No. 262, June 1976.

APPENDIX I

MODIFICATIONS TO INCLUDE VARIABLE HEADINGS

SAMPLE DERIVATION

For example, the term in Equation 12 becomes

$$I = -i\omega \int V \frac{\partial m'}{\partial x} e^{-kd^*} e^{ikx(-\cos\beta)} X(x)\, dx$$

$$I = -i\omega \int V e^{-kd^*} e^{ikx(-\cos\beta)} X(x)\, dm'$$

Now integrate by parts,

$$I = -i\omega \left\{ \underbrace{\left[m' V e^{-kd^*} e^{ikx(-\cos\beta)} X(x) \right]_L}_{\text{Eqn. 12(h)}} \underbrace{- \int m' \, d\left(V e^{-kd^*} e^{ikx(-\cos\beta)} X(x)\right)}_{A} \right\}$$

$$-i\omega A = \underbrace{i\omega V \int m' e^{-kd^*} e^{ikx(-\cos\beta)} \frac{dX(x)}{dx}}_{\text{Eqn. 12(i)}} + \underbrace{i\omega V \int X(x)\, m' \, d \frac{\left[e^{-kd^*} e^{ikx(-\cos\beta)}\right]}{dx}}_{B}$$

$$B = i\omega V \int m' X(x) e^{-kd^*} e^{ikx(-\cos\beta)} (-ik\text{-}\cos\beta)\, dx$$

$$= (-\cos\beta) \underbrace{\left[-\omega V k \int m' X(x) e^{-kd^*} e^{ikx(-\cos\beta)} dx \right]}_{\text{Eqn. 12(k)}}$$

$$= (-\cos\beta) * \text{Eqn. 12(k)}$$

COMPARISON OF HEAD SEAS PROGRAM (NO. 1) AND VARIABLE HEADING (NO.2)

```
14.227 SEC.  170 I/O
READY

TEX

ENTER MATCH SIZE? 2
 2      125 COMMON /HEAD/ COSB,WAVEN1,ANS1(3),BETAD

 2      270 XX=-2.0*UOB*COSB/GRAV
 2      271 IF(XX. GT .1.E-6)GO TO 6
 2      272 OMEGA=OMEGAE
 2      273 GO TO 7
 2      274 6CONTINUE
 2      275 DEF=1.0+2.0*XX*OMEGAE
 2      276 IF(DEF. LT .0.)GO TO 9
 2      278 OMEGA=(SQRT(DEF)-1.0)/XX
 2      279 7CONTINUE
 2      290 WAVEN=OMEGA*OMEGA/GRAV
 2      292 WAVEN1=-WAVEN*COSB
 2      300 ANS(IZ,2)=2.*PI/WAVEN1
 1      270 XX=2.0*UOB/GRAV
 1      280 OMEGA=(SQRT(1.0+2.0*XX*OMEGAE)-1.0)/XX
 1      290 WAVEN=OMEGA*OMEGA/GRAV
 1      300 ANS(IZ,2)=2.*PI/WAVEN

 2      352 ANS1(IZ)=BETAD

 2      442 GO TO 10
 2      444 9CONTINUE
 2      446 WRITE(NTAPE4,91)
 2      447 91FORMAT(//5X,36HOMEGA IS UNDEFINED; CASE TERMINATES.,/,14X,20HFR'
 2      448 &HEADING.)
 2      449 10CONTINUE

 2      502 COMMON /HEAD/ COSB,WAVEN1,ANS1(3),BETAD

 2     1192 WRITE(NTAPE4,102)
 2     1194 READ(NTAPE1,103) BETAD
 2     1196 COSB=COS(PI*BETAD/180.0)

 2     1311 102FORMAT(1X,7HHEADING)
 2     1312 103FORMAT(F10.0)

 2     1842 COMMON /HEAD/ COSB,WAVEN1,ANS1(3),BETAD

 2     2090 CREX(I)=CMPLX(-WAVEN*DST(I),WAVEN1*XI(I))
 1     2090 CREX(I)=CMPLX(-WAVEN*DST(I),WAVEN*XI(I))
```

```
2      2190 FEX(5)=COMPA*UOB*WAVEN1*CYMPS
1      2180 CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
1      2190 FEX(5)=COMPA*UOB*WAVEN*CYMPS

2      2250 FEX(4)=-OMEGA*UOB*WAVEN1*CYMPS
1      2240 CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
1      2250 FEX(4)=-OMEGA*UOB*WAVEN*CYMPS

2      2702 COMMON /HEAD/ COSB,WAVEN1,ANS1(3),BETAD

2      3130 FEX(11)=-COMPA*UOB*WAVEN1*CYMPS
1      3130 FEX(11)=-COMPA*UOB*WAVEN*CYMPS

2      3180 FEX(4)=OMEGA*UOB*WAVEN1*CYMPS
1      3180 FEX(4)=OMEGA*UOB*WAVEN*CYMPS

2      3782 COMMON /HEAD/ COSB,WAVEN1,ANS1(3),BETAD

2      3860 TH=WAVEN1*SPACE
1      3860 TH=WAVEN*SPACE

2      4192 COMMON /HEAD/ COSB,WAVEN1,ANS1(3),BETAD

2      4220 & UNITHD*6,UNITF*6,UNITBM*6,UNITHD*6
2      4230 CHARACTER DNAME*21,DNAME1*21
2      4240 DIMENSION DNAME(26)
2      4250 DATADNAME/21HSHIP/EFF. WAVE LENGTH,
2      4260 &            21HEFFECTIVE WAVE LENGTH,
1      4220 & UNITND*6,UNITF*6,UNITBM*6
1      4230 CHARACTER DNAME*21
1      4240 DIMENSION DNAME(26)
1      4250 DATADNAME/21HSHIP/WAVE LENGTH        ,
1      4260 &            21HWAVE LENGTH           ,

2      4502 DATADNAME1/21HSHIP HEADING          /

2      4531 DATAUNITHD/6H DEG. /

2      4682 WRITE(NTAPE4,92)DNAME1    ,UNITHD,(ANS1(L)   ,L=1,J)

12.352 SEC.   80 I/O
READY
```

APPENDIX II

PROGRAM LISTING AND OFFSET FILES

LIST
SPM2G163 29 DEC 80 15:12

```
$:::SPM2G163 IS AN UPDATE VERSION OF SPM2G162.
$:::THE FORMER INCLUDES THE EFFECT OF WAVE HEADINGS.
 REAL MUCCOR,KM,MOMBAR
 COMPLEXCO,CYMPS,FEX,FEX1,CREX
 CHARACTERDAY,PRO*6
 COMMON /HEAD/ COSB,WAVEN1,ANS1(3),BETAD
 COMMONDAY(2),PRO(4),ANS(3,26),IZ,SCALE,NTAPE1,NTAPE2,NTAPE3,NTAPE4
 COMMONPI,GRAV,RO,GAMMA,BPL,XDEL,XI(161),Y(161),DST(161),
&QUANT(161),BEEP(161),DXDX(161),DDDX(161),WGT(161),O(161),CO(161),
&UOB,OMEGA,OMEGAE,OMEGAR,WAVEN,NSTA,MS
 COMMONEPS,FEX(20),FBAR,KM,PHI,MOMBAR,ZBBAR,CSMU
 COMMONCAPX(161),YB(21,41),ZB(21,41),NPTS(161),MUCCOR,ENCOR,CREX(161),FEX1
 DATAISN/1/,NPAGE/0/
 CALLINPUT(V1,DELV,NWE1,OM1,DELOM,NWE2)
 IZ=0
 DO8NFR=1,NWE1
 UOB=V1+(NFR-1)*DELV
 DO8IJ1=1,NWE2
 IZ=IZ+1
 OMEGAE=OM1+(IJ1-1)*DELOM
 XX=-2.0*UOB*COSB/GRAV
 IF(XX.GT.1.E-6)GO TO 6
 OMEGA=OMEGAE
 GO TO 7
 6CONTINUE
 DET=1.0+2.0*XX*OMEGAE
 IF(DET.LT.0.)GO TO 9
 OMEGA=(SQRT(DET)-1.)/XX
 7CONTINUE
 WAVEN=OMEGA*OMEGA/GRAV
 WAVEN1=-WAVEN*COSB
 ANS(IZ,2)=2.*PI/ABS(WAVEN1)
 ANS(IZ,1)=BPL/ANS(IZ,2)
 ANS(IZ,2)=ANS(IZ,2)*SCALE
 ANS(IZ,3)=OMEGAE/SQRT(SCALE)
 ANS(IZ,4)=OMEGAR/SQRT(SCALE)
 ANS(IZ,5)=SQRT(SCALE)*UOB
 ANS1(IZ)=BETAD
 CALLSPADCR
 CALLSPEXCI
 CALLSPVIBM
 IF(IZ.NE.3)GOTO8
 CALLOUTPUT(ISN,NPAGE)
 IZ=0
 8CONTINUE
 IZ=-IZ
 CALLOUTPUT(ISN,NPAGE)
 GO TO 10
 9CONTINUE
 WRITE(NTAPE4,91)
 91FORMAT(//5X,36HOMEGA IS UNDEFINED; CASE TERMINATES.,/,14X,20HTRY ANOTHER
&HEADING.)
 10CONTINUE
 STOP001
 END
 SUBROUTINEINPUT(V1,DELV,NWE1,OM1,DELOM,NWE2)
 REALMUCCOR,KM,MOMBAR
 COMPLEXCO,CYMPS,FEX,FEX1,CREX
 CHARACTER FILNM1,FILNM2,PRO*6,DAY,FILNM3
 COMMON /HEAD/ COSB,WAVEN1,ANS1(3),BETAD
 COMMONDAY(2),PRO(4),ANS(3,26),IZ,SCALE,NTAPE1,NTAPE2,NTAPE3,NTAPE4
 COMMONPI,GRAV,RO,GAMMA,BPL,XDEL,XI(161),Y(161),DST(161),
&QUANT(161),BEEP(161),DXDX(161),DDDX(161),WGT(161),O(161),CO(161),
&UOB,OMEGA,OMEGAE,OMEGAR,WAVEN,NSTA,MS
 COMMONEPS,FEX(20),FBAR,KM,PHI,MOMBAR,ZBBAR,CSMU
 COMMONCAPX(161),YB(21,41),ZB(21,41),NPTS(161),MUCCOR,ENCOR,CREX(161),FEX1
 DATAPI/3.1415926536/,GRAV/32.174/,RO/1.9384/
 DATANTAPE1/0/,NTAPE2/1/,NTAPE3/2/,NTAPE4/0/
 SCALE=1.
 DAY(1)=DATE
 DAY(2)=TIME
```

```
GAMMA=GRAV*RO
WRITE(NTAPE1,94)
READ(NTAPE1,100)FILNM1
OPENFILE NTAPE2,FILNM1
READ(NTAPE2,100)PRO
READ(NTAPE2,96)BPL,NSTA
NSTA=161
MS=0.5*NSTA+1
XDEL=BPL/(NSTA-1)
DO5I=1,NSTA
5XI(I)=(I-MS)*XDEL
READ(NTAPE2,96)OMEGAR
READ(NTAPE2,96)CSMU
CSMU=0.
READ(NTAPE2,101)(QUANT(I),BEEP(I),WGT(I),CAPX(I),I=1,NSTA,4)
DO21I=5,NSTA,4
DO21IK=1,3
IK1=I+IK-4
QUANT(IK1)=QUANT(I-4)+.25*IK*(QUANT(I)-QUANT(I-4))
BEEP(IK1)  =BEEP(I-4)+.25*IK*(BEEP(I)-BEEP(I-4))
CAPX(IK1) = CAPX(I-4)+.25*IK*(CAPX(I)-CAPX(I-4))
WGT(IK1)=WGT(I-4)+.25*IK*(WGT(I)-WGT(I-4))
21CONTINUE
DXDX(1)=(CAPX(2)-CAPX(1))/XDEL
DXDX(NSTA)=(CAPX(NSTA)-CAPX(NSTA-1))/XDEL
NM=NSTA-1
DO2I=2,NM
2DXDX(I)=(CAPX(I+1)-CAPX(I-1))/(XDEL+XDEL)
CLOSEFILE NTAPE2
WRITE(NTAPE1,95)
READ(NTAPE1,100)FILNM2
OPENFILE NTAPE3,FILNM2
READ(NTAPE3,90)TF,TA,NSTAOF
DO8I=1,NSTAOF
II=4*I-3
Y(II)=0.
READ(NTAPE3,97)STANO,NON
IF(NON.EQ.0)GOTO8
READ(NTAPE3,91)(ZB(J,I),J=1,NON)
READ(NTAPE3,91)(YB(J,I),J=1,NON)
Y(II)=YB(NON,I)
8NPTS(I)=NON
DO888I=5,NSTA,4
DO888IK=1,3
IK1=I+IK-4
Y(IK1)=Y(I-4)+.25*IK*(Y(I)-Y(I-4))
888CONTINUE
CLOSEFILE NTAPE3
WRITE(NTAPE1,92)
READ(NTAPE1,99)V1,V2,DELV
NWE1=1
IF(DELV.NE.0)NWE1=(V2-V1)/DELV+1
23WRITE(NTAPE1,93)
OM1=0.
READ(NTAPE1,99)OM1,OM2,DELOM
NWE2=1
IF(DELOM.NE.0)NWE2=(OM2-OM1)/DELOM+1
IF(OM1.EQ.0.)OM1=OMEGAR
WRITE(NTAPE4,102)
READ(NTAPE1,103) BETAD
COSB=COS(PI*BETAD/180.0)
26RETURN
90 FORMAT(1X,2F10.5,I5)
91 FORMAT(1X,7F10.5)
92FORMAT(1X,5HSPEED)
93FORMAT(1X,5HFREQ.)
94FORMAT(1X,19HSHIP DATA FILE NAME)
95FORMAT(1X,21HOFFSET DATA FILE NAME)
96FORMAT(F10.4,I5)
97 FORMAT(1X,F10.4,I5)
98FORMAT(1X,16HOUTPUT FILE NAME)
99FORMAT(F5.3,1X,F5.3,1X,F5.3)
100FORMAT(4A6)
101FORMAT(4F10.4)
102FORMAT(1X,7HHEADING)
103FORMAT(F10.0)
END
SUBROUTINESPADCR
REALMUCCOR,KM,MOMBAR
COMPLEXCO,CYMPS,FEX,FEX1,CREX
```

```
CHARACTER DAY,PRO*6
COMMONDAY(2),PRO(4),ANS(3,26),IZ,SCALE,NTAPE1,NTAPE2,NTAPE3,NTAPE4
COMMONPI,GRAV,RO,GAMMA,BPL,XDEL,XI(161),Y(161),DST(161),
&QUANT(161),BEEP(161),DXDX(161),DDDX(161),WGT(161),O(161),CO(161)
&,UOB,OMEGA,OMEGAE,OMEGAR,WAVEN,NSTA,MS
COMMONEPS,FEX(20),FBAR,KM,PHI,MOMBAR,ZBBAR,CSMU
COMMONCAPX(161),YB(21,41),ZB(21,41),NPTS(161),MUCCOR,ENCOR,CREX(161),FEX1
N=NSTA
IF(KK.GT.0)GOTO4
DO1I=1,N
1O(I)=QUANT(I)*CAPX(I)**2
UMH=S141(O,1,N,XDEL)
DO2I=1,N
2O(I)=WGT(I)*CAPX(I)**2
UMS=S141(O,1,N,XDEL)
DO3I=1,N
3O(I)=BEEP(I)*CAPX(I)*DXDX(I)
UMF=S141(O,1,N,XDEL)
DO5I=1,N
5O(I)=BEEP(I)*CAPX(I)**2
C1H=S141(O,1,N,XDEL)
DO6I=1,N
6O(I)=QUANT(I)*CAPX(I)*DXDX(I)
C2A=S141(O,1,N,XDEL)
4UME=(BEEP(N)*CAPX(N)**2-BEEP(1)*CAPX(1)**2)
UME=UOB*(UME-2.*UMF)/OMEGAR**2
C2H=QUANT(N)*CAPX(N)**2-QUANT(1)*CAPX(1)**2
C2H=-UOB*(C2H-2.*C2A)
UME=-BEEP(1)*UOB/OMEGAR**2
C2H=QUANT(1)*UOB
MUCCOR=UMH+UMS+UME
C3H=(UMH+UMS)*SPEXEN(OMEGAR,CSMU)
ENCOR=C1H+C2H+C3H
COMU=ENCOR/MUCCOR
ANS(IZ,6)=SCALE**3*UMH
ANS(IZ,7)=SCALE**3*UMS
ANS(IZ,8)=SCALE**3*UME
ANS(IZ,9)=SCALE**3*MUCCOR
SCALE5=SQRT(SCALE**5)
ANS(IZ,10)=SCALE5*C1H
ANS(IZ,11)=SCALE5*C2H
ANS(IZ,12)=SCALE5*C3H
ANS(IZ,13)=SCALE5*ENCOR
ANS(IZ,14)=COMU/SQRT(SCALE)
KK=KK+1
RETURN
END
SUBROUTINESPEXCI
REALMUCCOR,KM,MOMBAR
COMPLEXCO,CYMPS,FEX,FEX1,FEX2,CREX,COMPA
CHARACTER DAY,PRO*6
COMMON /HEAD/ COSB,WAVEN1,ANS1(3),BETAD
COMMONDAY(2),PRO(4),ANS(3,26),IZ,SCALE,NTAPE1,NTAPE2,NTAPE3,NTAPE4
COMMONPI,GRAV,RO,GAMMA,BPL,XDEL,XI(161),Y(161),DST(161),
&QUANT(161),BEEP(161),DXDX(161),DDDX(161),WGT(161),O(161),CO(161),
&UOB,OMEGA,OMEGAE,OMEGAR,WAVEN,NSTA,MS,EPS,FEX(20),
&FBAR,KM,PHI,MOMBAR,ZBBAR,CSMU
COMMONCAPX(161),YB(21,41),ZB(21,41),NPTS(161),MUCCOR,ENCOR,CREX(161),FEX1
N=NSTA
COMPA=CMPLX(0.0,1.0)
CALLSPSTAR(YB,ZB,NPTS,41,WAVEN,O)
DST(1)=O(1)
DO88I=2,41
IK1=4*I-6
IK2=4*I-3
IKO=0
DO88IK=IK1,IK2
IKO=IKO+1
DST(IK)=O(I-1)+IKO*.25*(O(I)-O(I-1))
88CONTINUE
DDDX(1)=(DST(2)-DST(1))/XDEL
DDDX(N)=(DST(N)-DST(N-1))/XDEL
NM=NSTA-1
DO8I=2,NM
8DDDX(I)=(DST(I+1)-DST(I-1))/(XDEL+XDEL)
DO1I=1,N
CREX(I)=CMPLX(-WAVEN*DST(I),WAVEN1*XI(I))
CO(I)=Y(I)*CAPX(I)*CEXP(CREX(I))
1CONTINUE
CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
FEX(1)=2.*GAMMA*CYMPS
DO2I=1,N
```

```
2150 2CO(I)=BEEP(I)*CAPX(I)*CEXP(CREX(I))
2160 CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
2170 FEX(2)=COMPA*OMEGA*CYMPS
2190 FEX(5)=COMPA*UOB*WAVEN1*CYMPS
2200 DO3I=1,N
2210 3CO(I)=QUANT(I)*CAPX(I)*CEXP(CREX(I))
2220 CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
2230 FEX(3)=-OMEGA*OMEGA*CYMPS
2250 FEX(4)=-OMEGA*UOB*WAVEN1*CYMPS
2260 DO4I=1,N
2270 4CO(I)=QUANT(I)*DXDX(I)*CEXP(CREX(I))
2280 CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
2290 FEX(6)=COMPA*OMEGA*UOB*CYMPS
2300 DO5I=1,N
2310 5CO(I)=QUANT(I)*CAPX(I)*CEXP(CREX(I))*DDDX(I)
2320 CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
2330 FEX(7)=-COMPA*OMEGA*UOB*WAVEN*CYMPS
2340 DO6I=1,N
2350 6CO(I)=BEEP(I)*DXDX(I)*CEXP(CREX(I))
2360 CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
2370 FEX(8)=UOB*CYMPS
2380 DO7I=1,N
2390 7CO(I)=BEEP(I)*CAPX(I)*CEXP(CREX(I))*DDDX(I)
2400 CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
2410 FEX(9)=-WAVEN*UOB*CYMPS
2420 FEX(10)=QUANT(N)*CAPX(N)*CEXP(CREX(N))
2430 FEX(10)=FEX(10)-QUANT(1)*CAPX(1)*CEXP(CREX(1))
2440 FEX(10)=-COMPA*OMEGA*UOB*FEX(10)
2450 FEX(11)=BEEP(N)*CAPX(N)*CEXP(CREX(N))
2460 FEX(11)=-UOB*(FEX(11)-BEEP(1)*CAPX(1)*CEXP(CREX(1)))
2470 FEX1=FEX(1)
2480 DO9J=2,11
2490 9FEX1=FEX1+FEX(J)
2500 EPS=SPANGL(AIMAG(FEX1),REAL(FEX1))
2510 FBAR=CABS(FEX1)
2520 ALP1=OMEGAE*ENCOR/(OMEGAR**2*MUCCOR)
2530 ALP2=1.0-(OMEGAE/OMEGAR)**2
2540 KM=SQRT(ALP2**2+ALP1**2)
2550 KM=1.0000/KM
2560 PHI=SPANGL(ALP1,ALP2)
2570 ZBBAR=KM*FBAR/(OMEGAR**2*MUCCOR)
2580 ANS(IZ,15)=PHI
2590 ANS(IZ,16)=KM
2600 ANS(IZ,17)=SCALE**3*REAL(FEX1)
2610 ANS(IZ,18)=SCALE**3*AIMAG(FEX1)
2620 ANS(IZ,19)=SCALE**3*FBAR
2630 ANS(IZ,20)=EPS
2640 ANS(IZ,21)=SCALE*ZBBAR
2650 RETURN
2660 END
2670 SUBROUTINESPVIBM
2680 REALMUCCOR,KM,MOMBAR
2690 COMPLEXCO,CYMPS,FEX,ABCOP(3),MOM,COMPA,CREX,CEI1
2700 CHARACTER DAY,PRO*6
2702 COMMON /HEAD/ COSB,WAVEN1,ANS1(3),BETAD
2710 COMMONDAY(2),PRO(4),ANS(3,26),IZ,SCALE,NTAPE1,NTAPE2,NTAPE3,NTAPE4
2720 COMMONPI,GRAV,RO,GAMMA,BPL,XDEL,XI(161),Y(161),DST(161),
2730&QUANT(161),BEEP(161),DXDX(161),DDDX(161),WGT(161),O(161),CO(161)
2740&,UOB,OMEGA,OMEGAE,OMEGAR,WAVEN,NSTA,MS,EPS,FEX(20),
2750&FBAR,KM,PHI,MOMBAR,ZBBAR,CSMU
2760 COMMONCAPX(161),YB(21,41),ZB(21,41),NPTS(161),MUCCOR,ENCOR,CREX(161),FEX1
2770 COMPA=CMPLX(0.,1.)
2780 N=MS
2790 EPS1=PHI-EPS
2800 CEI1=CEXP(COMPA*EPS1)
2810 DO1I=1,N
2820 1O(I)=Y(I)*CAPX(I)*XI(I)
2830 FEX(12)=CEI1*2.*GAMMA*S141(O,1,N,XDEL)
2840 DO2I=1,N
2850 2O(I)=(WGT(I)+QUANT(I))*CAPX(I)*XI(I)
2860 FEX(14)=-CEI1*OMEGAE*OMEGAE*S141(O,1,N,XDEL)
2870 DO3I=1,N
2880 3O(I)=BEEP(I)*CAPX(I)*XI(I)
2890 FEX(13)=CEI1*COMPA*OMEGAE*S141(O,1,N,XDEL)
2900 D=-OMEGAE*UOB*(QUANT(N)*CAPX(N)*XI(N)-QUANT(1)*CAPX(1)*XI(1))
2910 FEX(18)=COMPA*CEI1*D
2920 FEX(15)=-CEI1*UOB*(BEEP(N)*CAPX(N)*XI(N)-BEEP(1)*CAPX(1)*XI(1))
2930 DO4I=1,N
2940 4O(I)=QUANT(I)*XI(I)*DXDX(I)
2950 FEX(20)=CEI1*COMPA*OMEGAE*UOB*S141(O,1,N,XDEL)
```

```
DO5I=1,N
5O(I)=BEEP(I)*XI(I)*DXDX(I)
FEX(17)=CEI1*UOB*S141(O,1,N,XDEL)
DO6I=1,N
6O(I)=QUANT(I)*CAPX(I)
FEX(19)=CEI1*COMPA*OMEGAE*UOB*S141(O,1,N,XDEL)
DO7I=1,N
7O(I)=BEEP(I)*CAPX(I)
FEX(16)=CEI1*UOB*S141(O,1,N,XDEL)
DO8I=1,N
8CO(I)=Y(I)*XI(I)*CEXP(CREX(I))
CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
FEX(1)=-2.*GAMMA*CYMPS
DO9I=1,N
9CO(I)=BEEP(I)*XI(I)*CEXP(CREX(I))
CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
FEX(2)=-COMPA*OMEGA*CYMPS
FEX(11)=-COMPA*UOB*WAVEN1*CYMPS
DO10I=1,N
10CO(I)=QUANT(I)*XI(I)*CEXP(CREX(I))
CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
FEX(3)=OMEGA*OMEGA*CYMPS
FEX(4)=OMEGA*UOB*WAVEN1*CYMPS
FEX(5)=QUANT(N)*XI(N)*CEXP(CREX(N))
FEX(5)=COMPA*OMEGA*UOB*(FEX(5)-QUANT(1)*XI(1)*CEXP(CREX(1)))
DO11I=1,N
11CO(I)=QUANT(I)*CEXP(CREX(I))
CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
FEX(6)=-COMPA*OMEGA*UOB*CYMPS
DO12I=1,N
12CO(I)=QUANT(I)*XI(I)*CEXP(CREX(I))*DDDX(I)
CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
FEX(7)=COMPA*WAVEN*OMEGA*UOB*CYMPS
DO13I=1,N
13CO(I)=BEEP(I)*CEXP(CREX(I))
CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
FEX(9)=-UOB*CYMPS
FEX(8)=BEEP(N)*XI(N)*CEXP(CREX(N))
FEX(8)=UOB*(FEX(8)-BEEP(1)*XI(1)*CEXP(CREX(1)))
DO14I=1,N
14CO(I)=BEEP(I)*XI(I)*CEXP(CREX(I))*DDDX(I)
CALLSPCOMP(WAVEN,CYMPS,CO,1,N,XDEL)
FEX(10)=WAVEN*UOB*CYMPS
CO(10)=(0.,0.)
DO16I=1,20
16CO(10)=CO(10)+FEX(I)
EPS2=SPANGL(AIMAG(CO(10)),REAL(CO(10)))
MOM=CO(10)*ZBBAR
MOMBAR=CABS(MOM)
ANS(IZ,22)=EPS1
ANS(IZ,23)=SCALE**3*REAL(MOM)
ANS(IZ,24)=SCALE**3*AIMAG(MOM)
ANS(IZ,25)=SCALE**3*MOMBAR
ANS(IZ,26)=EPS2
RETURN
END
FUNCTIONS141(O,N1,N2,ADEL)
DIMENSIONO(161)
B=1
SYMPS=(O(N1)+O(N2))
NOP=N2-1
NEP=N1+1
DO1I=NEP,NOP
SYMPS=SYMPS+2.*O(I)
1B=-B
S141=SYMPS*.5*ADEL
RETURN
END
FUNCTIONSPANGL(YDUM,XDUM)
FEEDUM=ATAN2(YDUM,XDUM)
IF(FEEDUM.LT.0.0)FEEDUM=6.283185+FEEDUM
SPANGL=FEEDUM
RETURN
END
FUNCTIONSPEXEN(OMEGAR,CSMU)
DATAC/50.958483465/,D/1.714975945 4/
CSMUT=CSMU
IF(CSMU.LT.1.E-10)CSMUT=(OMEGAR/C)**D
SPEXEN=CSMUT
RETURN
END
```

```
SUBROUTINESPCOMP(WAVEN,CYMPS,CO,N1,NEND,SPACE)
COMPLEXCO,CYMPS,CTE,CTO
COMMON /HEAD/ COSB,WAVEN1,ANS1(3),BETAD
DIMENSIONCO(161)
CTE=0.5*(CO(NEND)-CO(N1))
CTO=(0.0,0.0)
NOP=N1+1
DO10I=NOP,NEND,2
CTE=CTE+CO(I-1)
10CTO=CTO+CO(I)
TH=WAVEN1*SPACE
ST=SIN(TH)
CT=COS(TH)
GA=TH*TH*TH
AL=(TH*(TH+ST*CT)-2.*ST*ST)/GA
BE=(2.*(TH*(1.+CT*CT)-2.*ST*CT))/GA
GA=(4.*(ST-TH*CT))/GA
CTE=BE*CTE+GA*CTO
CTO=AL*(CO(NEND)-CO(1))
AL=SPACE*(AIMAG(CTO)+REAL(CTE))
BE=SPACE*(-REAL(CTO)+AIMAG(CTE))
CYMPS=CMPLX(AL,BE)
RETURN
END
SUBROUTINESPSTAR(Y,Z,NPTS,N,K,DSTAR)
DIMENSIONDSTAR(161),Y(21,41),Z(21,41),NPTS(161)
REALK
DO1J=1,N
NP=NPTS(J)
SUM=0.
IF(NP.EQ.0)GOTO1
DO2I=2,NP
ZP=.5*(Z(I,J)+Z(I-1,J))
ZM=.5*(Z(I,J)-Z(I-1,J))
YP=Y(I,J)+Y(I-1,J)
PSUM=ZM*YP*EXP(K*ZP)
2SUM=SUM+PSUM
SUM=1.-K*SUM/Y(NP,J)
SUM=-ALOG(SUM)/K
1DSTAR(J)=SUM
RETURN
END
SUBROUTINEOUTPUT(ISN,NPAGE)
CHARACTERDAY,PRO*6
COMMON /HEAD/ COSB,WAVEN1,ANS1(3),BETAD
COMMONDAY(2),PRO(4),ANS(3,26),J,SCALE,NTAPE1,NTAPE2,NTAPE3,NTAPE4
CHARACTERUNITAC*6,UNITL*6,UNITFQ*6,UNITVL*6,UNITM*6,
& UNITND*6,UNITF*6,UNITBM*6,UNITHD*6
CHARACTER DNAME*21,DNAME1*21
DIMENSION DNAME(26)
DATADNAME/21HSHIP/EFF. WAVE LENGTH,
&          21HEFFECTIVE WAVE LENGTH,
&          21HENCOUNTER FREQUENCY  ,
&          21HRESONANT FREQUENCY   ,
&          21HSPEED                ,
&          21HHYDRODYNAMIC A.M.    ,
&          21HSHIP MASS            ,
&          21HSPEED DEPENDENT A.M. ,
&          21HTOTAL ADDED MASS     ,
&          21HHYDRODYNAMIC DAMPING ,
&          21HSPEED DEPENDENT DAMP.,
&          21HSTRUCTURAL DAMPING   ,
&          21HTOTAL DAMPING        ,
&          21HDAMPING/ADDED MASS   ,
&          21HPHI-FORCE & MOTION   ,
&          21HMAGNIFICATION FACTOR ,
&          21HF COS(EPS)           ,
&          21HF SIN(EPS)           ,
&          21HF-WAVE EXCITING FORCE,
&          21HEPS-FORCE & WAVE     ,
&          21HDEFLECTION AT STERN  ,
&          21HEPS1-WAVE & VIBRATION,
&          21HM COS(EPS2)          ,
&          21HM SIN(EPS2)          ,
&          21HM-BENDING MOMENT AMID,
&          21HEPS2-WAVE & B.M.     /
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4502 DATADNAME1/21HWAVE HEADING          /
4510 DATAUNITAG/6H RAD. /,UNITL/6H FEET /,UNITFQ/6H1/SEC./,
4520& UNITVL/6HFT/SEC/,UNITM/6H SLUGS/,UNITND/6HNON-D./,
4530& UNITF/6H LBS. /,UNITBM/6HFT-LBS/
4531 DATAUNITHD/6H DEG. /
4540 INDEX=1
4550 IF(J.LE.0)INDEX=0
4560 IF(ISN.EQ.-1.AND.J.EQ.0)GOTO2
4570 IF(J.EQ.0)GOTO3
4580 IF(ISN.NE.1)GOTO1
4590 IF(J.LT.0)INDEX=-1
4600 NPAGE=NPAGE+1
4610 WRITE(NTAPE4,91)PRO,DAY(1),DAY(2),NPAGE
4620 1WRITE(NTAPE4,89)
4630 J=IABS(J)
4640 WRITE(NTAPE4,92)DNAME( 1),UNITND,(ANS(L, 1),L=1,J)
4650 WRITE(NTAPE4,92)DNAME( 2),UNITL ,(ANS(L, 2),L=1,J)
4660 WRITE(NTAPE4,92)DNAME( 3),UNITFQ,(ANS(L, 3),L=1,J)
4670 WRITE(NTAPE4,92)DNAME( 4),UNITFQ,(ANS(L, 4),L=1,J)
4680 WRITE(NTAPE4,92)DNAME( 5),UNITVL,(ANS(L, 5),L=1,J)
4682 WRITE(NTAPE4,92)DNAME1    ,UNITHD,(ANS1(L)   ,L=1,J)
4690 WRITE(NTAPE4,93)DNAME( 6),UNITM ,(ANS(L, 6),L=1,J)
4700 WRITE(NTAPE4,93)DNAME( 7),UNITM ,(ANS(L, 7),L=1,J)
4710 WRITE(NTAPE4,93)DNAME( 8),UNITM ,(ANS(L, 8),L=1,J)
4720 WRITE(NTAPE4,93)DNAME( 9),UNITM ,(ANS(L, 9),L=1,J)
4730 WRITE(NTAPE4,94)DNAME(10),UNITM ,(ANS(L,10),L=1,J)
4740 WRITE(NTAPE4,94)DNAME(11),UNITM ,(ANS(L,11),L=1,J)
4750 WRITE(NTAPE4,94)DNAME(12),UNITM ,(ANS(L,12),L=1,J)
4760 WRITE(NTAPE4,94)DNAME(13),UNITM ,(ANS(L,13),L=1,J)
4770 WRITE(NTAPE4,92)DNAME(14),UNITFQ,(ANS(L,14),L=1,J)
4780 WRITE(NTAPE4,92)DNAME(15),UNITAG,(ANS(L,15),L=1,J)
4790 WRITE(NTAPE4,93)DNAME(16),UNITND,(ANS(L,16),L=1,J)
4800 WRITE(NTAPE4,93)DNAME(17),UNITF ,(ANS(L,17),L=1,J)
4810 WRITE(NTAPE4,93)DNAME(18),UNITF ,(ANS(L,18),L=1,J)
4820 WRITE(NTAPE4,93)DNAME(19),UNITF ,(ANS(L,19),L=1,J)
4830 WRITE(NTAPE4,92)DNAME(20),UNITAG,(ANS(L,20),L=1,J)
4840 WRITE(NTAPE4,93)DNAME(21),UNITL ,(ANS(L,21),L=1,J)
4850 WRITE(NTAPE4,92)DNAME(22),UNITAG,(ANS(L,22),L=1,J)
4860 WRITE(NTAPE4,93)DNAME(23),UNITF ,(ANS(L,23),L=1,J)
4870 WRITE(NTAPE4,93)DNAME(24),UNITF ,(ANS(L,24),L=1,J)
4880 WRITE(NTAPE4,93)DNAME(25),UNITF ,(ANS(L,25),L=1,J)
4890 WRITE(NTAPE4,92)DNAME(26),UNITAG,(ANS(L,26),L=1,J)
4900 ISN=-ISN
4910 5IF(INDEX)2,3,4
4920 2WRITE(NTAPE4,95)
4930 3WRITE(NTAPE4,96)
4940 4RETURN
4950 89FORMAT(//)
4960 91FORMAT(/////,10(1H-),//,2X,5HSPM2Z,3X,4A6,5X,A8,4X,A8,5X,
4970& 4HPAGE,I3,/)
4980 92FORMAT(1X,A21,1H(,A6,1H),4X,3F12.3)
4990 93FORMAT(1X,A21,1H(,A6,1H),4X,1P3E12.4)
5000 94FORMAT(1X,A21,1H(,A6,4H/SEC,1H),1P3E12.4)
5010 95FORMAT(28(/))
5020 96FORMAT(3(/),10(1H-),5(/))
5030 END
READY
```

```
LIST

DFCOR1    29 DEC 80  14:37

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   10.0000    9
  -4.10001  -3.63300  -3.16701  -2.70000  -2.23300  -1.76700    .00000
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 -20.00000 -19.66699 -19.33299 -19.00000 -18.66699 -18.33299 -18.00000
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  52.30200  52.30200  52.30200  52.30200  52.30200  52.33961
    8.0000   20
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  32.45500  37.09100  41.72701  46.36400  51.00000  51.80000  52.30200
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  52.30200  52.30200  52.30200  52.30200  52.30200  52.33961
    7.5000   20
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  32.45500  37.09100  41.72701  46.36400  51.00000  51.80000  52.30200
  52.30200  52.30200  52.30200  52.30200  52.30200  52.33961
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   .00000   4.63600   9.27300  13.90900  18.54500  23.18201  27.81799
 32.45500  37.09100  41.72701  46.36400  51.00000  51.80000  52.30200
 52.30200  52.30200  52.30200  52.30200  52.30200  52.33961
    7.0000    20
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 32.45500  37.09100  41.72701  46.36400  51.00000  51.80000  52.30200
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   .00000   4.63600   9.27300  13.90900  18.54500  23.18201  27.81799
 32.45500  37.09100  41.72701  46.36400  51.00000  51.80000  52.30200
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    6.5000    20
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   .00000   4.63600   9.27300  13.90900  18.54500  23.18201  27.81799
 32.45500  37.09100  41.72701  46.36400  51.00000  51.80000  52.30200
 52.30200  52.30200  52.30200  52.30200  52.30200  52.33961
    6.2500    20
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   .00000   4.63606   9.27300  13.90900  18.54500  23.18201  27.81799
 32.45500  37.09100  41.72701  46.36400  51.00000  51.80000  52.30200
 52.30200  52.30200  52.30200  52.30200  52.30200  52.33961
    6.0000    20
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-15.01999	-10.07999	-5.13999	-.20000	.00000		
.00000	4.63600	9.27300	13.90900	18.54500	23.18201	27.81799
32.45500	37.09100	41.72701	46.36400	51.00000	51.80000	52.30200
52.30200	52.30200	52.30200	52.30200	52.30200		
523.9500	19					
-20.90799	-20.90799	-20.90799	-20.90799	-20.90799	-20.90799	-20.90799
-20.90799	-20.90799	-20.90799	-20.90799	-20.90799	-20.40799	-19.90799
-14.96799	-10.02799	-5.08799	-.14800	.00000		
.00000	4.63600	9.27300	13.90900	18.54500	23.18201	27.81799
32.45500	37.09100	41.72701	46.36400	51.00000	51.80000	52.30200
52.30200	52.30200	52.30200	52.30200	52.30200		
548.8999	19					
-20.85599	-20.85599	-20.85599	-20.85599	-20.85599	-20.85599	-20.85599
-20.85599	-20.85599	-20.85599	-20.85599	-20.85599	-20.35599	-19.85599
-14.91599	-9.97599	-5.03599	-.09599	.00000		
.00000	4.63600	9.27300	13.90900	18.54500	23.18201	27.81799
32.45500	37.09100	41.72701	46.36400	51.00000	51.80000	52.30200
52.30200	52.30200	52.30200	52.30200	52.30200		
573.8501	19					
-20.80399	-20.80399	-20.80399	-20.80399	-20.80399	-20.80399	-20.80399
-20.80399	-20.80399	-20.80399	-20.80399	-20.80399	-20.30399	-19.80399
-14.86399	-9.92399	-4.98399	-.04399	.00000		
.00000	4.63600	9.27300	13.90900	18.54500	23.18201	27.81799
32.45500	37.09100	41.72701	46.36400	51.00000	51.80000	52.30200
52.30200	52.30200	52.30200	52.30200	52.30200		
598.8000	18					
-20.75198	-20.75198	-20.75198	-20.75198	-20.75198	-20.75198	-20.75198
-20.75198	-20.75198	-20.75198	-20.75198	-20.75198	-20.25198	-19.75198
-14.81198	-9.87198	-4.93198	.00000			
.00000	4.63600	9.27300	13.90900	18.54500	23.18201	27.81799
32.45500	37.09100	41.72701	46.36400	51.00000	51.80000	52.30200
52.30200	52.30200	52.30200	52.30200			

623.7500	18					
-20.70000	-20.70000	-20.70000	-20.70000	-20.70000	-20.70000	-20.70000
-20.70000	-20.70000	-20.70000	-20.70000	-20.70000	-20.20000	-19.70000
-14.76000	-9.82000	-4.88000	.00000			
.00000	4.63600	9.27300	13.90900	18.54500	23.18201	27.81799
32.45500	37.09100	41.72601	46.36400	51.00000	51.80000	52.30200
52.30200	52.30200	52.30200	52.30200			
648.7000	18					
-20.64799	-20.64799	-20.64799	-20.64799	-20.64799	-20.64799	-20.64799
-20.64799	-20.64799	-20.64799	-20.64799	-20.64799	-20.14799	-19.64799
-14.70800	-9.76800	-4.82800	.00000			
.00000	4.63600	9.27300	13.90900	18.54500	23.18201	27.81799
32.45500	37.09100	41.72701	46.36400	51.00000	51.80000	52.30200
52.30200	52.30200	52.30200	52.30200			
673.6499	18					
-20.59599	-20.59599	-20.59599	-20.59599	-20.59599	-20.59599	-20.59599
-20.59599	-20.59599	-20.59599	-20.59599	-20.59599	-20.09599	-19.59599
-14.65599	-9.71599	-4.77599	.00000			
.00000	4.63600	9.27300	13.90900	18 54500	23.18201	27.81799
3°.45500	37.09100	41.72701	46.36400	51.00000	51.80000	52.30200
52.30200	52.30200	52.30200	52.30200			
698.6001	18					
-20.54399	-20.54399	-20.54399	-20.54399	-20.54399	-20.54399	-20.54399
-20.54399	-20.54399	-20.54399	-20.54399	-20.54399	-20.04399	-19.54399
-14.60399	-9.66399	-4.72399	.00000			
.00000	4.63600	9.27300	13.90900	18.54500	23.18201	27.81799
32.45500	37.09100	41.72701	46.36400	51.00000	51.80000	52.30200
52.30200	52.30200	52.30200	52.30200			
723.5500	18					
-20.49199	-20.49199	-20.49199	-20.49199	-20.49199	-20.49199	-20.49199
-20.49199	-20.49199	-20.49199	-20.49199	-20.49199	-19.99199	-19.49199
-14.55199	-9.61199	-4.67199	.00000			
.00000	4.63600	9.27300	13.90900	18.54500	23.18201	27.81799
32.45500	37.09100	41.72701	46.36400	51.00000	51.80000	52.30200
52.30200	52 30200	52.30200	52.30200			
748.5000	18					
-20.43999	-20.43999	-20.43999	-20.43999	-20.43999	-20.43999	-20.43999
-20.43999	-20.43999	-20.43999	-20.43999	-20.43999	-19.93999	-19.43999
-14.49999	-9.55999	-4.61999	.00000			
.00000	4.63600	9.27300	13.90900	18.54500	23.18201	27.81799
32.45500	37.07100	41.72701	46.36400	51.00000	51.80000	52.30200
52.30200	52.30200	52.30200	52.30200			
773.4500	18					
-20.38799	-20.38799	-20.38799	-20.38799	-20.38799	-20.38799	-20.38799
-20.38799	-20.38799	-20.38799	-20.38799	-20.38799	-19.88799	-19.38799
-14.44799	-9.50799	-4.56799	.00000			
.00000	4.63600	9.27300	13.90900	18.54500	23.18201	27.81799
32.45500	37.09100	41.72701	46.36400	51.00000	51.80000	52.30200
52.30200	52.30200	52.30200	52.30200			
798.3999	18					
-20.33598	-20.33598	-20.33598	-20.33598	-20.33598	-20.33598	-20.33598
-20.33598	-20.33598	-20.33598	-20.33598	-20.33598	-19.83598	-19.33598
-14.39598	-9.45598	-4.51598	.00000			
.00000	4.63600	9.27300	13.90900	18.54500	23.18201	27.81799
32.45500	37.09100	41.72701	46.36400	51.00000	51.80000	52.30200
52.30200	52.30200	52.30200	52.30200			
823.3499	18					
-20.28400	-20.28400	-20.28400	-20.28400	-20.28400	-20.28400	-20.28400
-20.28400	-20.28400	-20.28400	-20.28400	-20.28400	-19.78400	-19.28400
-14.34400	-9.40400	-4.46400	.00000			
.00000	4.63600	9.27300	13.90900	18.54500	23.18201	27.81799
32.45500	37.09100	41.72701	46.36400	51.00000	51.80000	52.30200
52.30200	52.30200	52.30200	52.30200			
848.2998	19					
-20.23199	-20.23199	-20.23199	-20.23199	-20.23199	-20.23199	-20.23199
-20.23199	-20.23199	-20.23199	-20.23199	-20.23199	-19.73199	-19.23199
-18.23199	-13.49199	-8.75200	-4.01199	.00000		
.00000	4.54500	9.09100	13.63600	18.18201	22.72701	27.27299
31.81799	36.36400	40.90900	45.45500	50.00000	51.20000	51.50000
52.30200	52.30200	52.30200	52.30200	52.30200		
873.2500	19					
-20.17999	-20.17999	-20.17999	-20.17999	-20.17999	-20.17999	-20.17999
-20.17999	-20.17999	-20.17999	-19.17999	-18.17999	-17.17999	-16.17999
-15.17999	-11.03999	-6.89999	-2.76000	.00000		
.00000	5.33300	10.66700	16.00000	21.33299	26.66701	32.00000
37.33299	42.66701	48.00000	50.00000	50.80000	51.30000	51.80000
52.30200	52.30200	52.30200	52.30200	52.30200		

```
 898.2000   19
-20.12799 -20.12799 -20.12799 -20.12799 -20.12799 -20.12799 -20.12799
-20.12799 -20.12799 -20.12799 -19.62799 -19.12799 -18.12799 -16.12799
-14.12799 -11.12799  -8.12799  -3.56099    .00000
   .00000   4.88900   9.77800  14.66700  19.55600  24.44400  29.33299
 34.22200  39.11099  44.00000  47.20000  47.30000  48.50000  49.70000
 50.60001  51.50000  52.30200  52.30200  52.30200
 923.1499   19
-20.07599 -20.07599 -20.07599 -20.07599 -20.07599 -20.07599 -20.07599
-20.07599 -20.07599 -19.57599 -19.07599 -18.07599 -16.07599 -14.07599
-11.07599  -8.07599  -5.07599  -2.07599    .00000
   .00000   4.75000   9.50000  14.25000  19.00000  23.75000  28.50000
 33.25000  38.00000  40.00000  41.00000  42.50000  44.60001  46.20000
 48.00000  49.00000  49.80000  50.25000  50.56139
 948.0999   17
-20.02399 -20.02399 -20.02399 -20.02399 -20.02399 -20.02399 -20.02399
-19.52399 -19.02399 -18.02399 -16.02399 -14.02399 -11.02399  -8.02399
 -5.02399  -2.02399    .00000
   .00000   4.33300   8.66700  13.00000  17.33299  21.66701  26.00000
 29.00000  30.30000  32.00000  34.60001  36.50000  38.89999  40.60001
 41.70000  42.80000  43.30600
 973.0498    6
-19.97198 -19.97198 -16.97198 -10.97198  -4.97199    .00000
   .00000   9.96000  17.98000  23.30000  25.70000  27.02586
 998.0000    0
READY
```

```
LIST

CASE1       18 DEC 80   14:14

S. J. CORT    CSE1
   998.0000   41
     2.2050
     0.0000
   825.3600  1038.6000   820.0000     1.0000
  6226.1900  2020.1841  2350.0000     0.9280
  8825.7000   123.7587  2400.0000     0.8160
 10033.7300     4.8660  2380.0000     0.7400
 10033.7300     4.8660  3772.0000     0.6240
 10192.6100     3.8361  3772.0000     0.5530
 10338.0400     1.3627  3772.0000     0.4590
 10481.4600     6.2250  3772.0000     0.3630
 10463.3199     6.3210  3772.0000     0.2720
 10472.5500     6.4150  4113.0000     0.1800
 10468.0699     6.4870  4113.0000     0.0880
 10463.5900     6.5490  4113.0000     0.0000
 10459.1100     6.6570  4113.0000    -0.0980
 10454.6300     6.7400  4113.0000    -0.1900
 10450.1500     6.7850  4113.0000    -0.2810
 10445.6700     6.8460  4113.0000    -0.3750
 10441.1899     6.9490  4113.0000    -0.4680
 10436.7100     7.0540  4113.0000    -0.5620
 10432.2800     7.3940  4113.0000    -0.6540
 10427.8000     7.4470  4113.0000    -0.7500
 10423.3199     7.3440  4113.0000    -0.8400
 10416.6600     7.7600  4113.0000    -0.7550
 10412.2800     7.8650  4113.0000    -0.6600
 10407.7000     7.7320  4113.0000    -0.5720
 10403.2200     7.9000  4113.0000    -0.4790
 10398.7400     8.0100  4113.0000    -0.3860
 10394.2600     8.1210  4113.0000    -0.2920
 10389.7800     8.1950  4113.0000    -0.1990
 10385.3500     8.2960  4113.0000    -0.1060
 10380.8199     8.3940  4113.0000    -0.0150
 10376.3900     8.5010  4113.0000     0.0800
 10370.7700     8.5840  4113.0000     0.1720
 10365.1400     8.6970  4113.0000     0.2630
 10362.9500     8.7510  4113.0000     0.3580
 10286.6300     1.3940  4113.0000     0.4500
 10013.6300     9.1770  3810.0000     0.5400
  9454.1899    56.1200  3810.0000     0.6300
  7973.9400   212.0896  4360.0000     0.7250
  5260.6300   360.0577  4360.0000     0.8180
  1858.5800   186.8018  1300.0000     0.9080
     0.0000     0.0000     0.0000     1.0000
READY
```

LIST

CASE 2 18 DEC 80 14:14

S. J. CORT CSE2

998.0000 41

2.2050

0.0000

825.3600	1038.6000	820.0000	1.0000
6226.1900	2020.1841	2350.0000	0.9280
8825.7000	123.7587	2400.0000	0.8160
10033.7300	4.8660	2380.0000	0.7400
10033.7300	4.8660	3772.0000	0.6240
10192.6100	3.8361	3772.0000	0.5530
10338.0400	1.3627	3772.0000	0.4590
10481.4600	6.2250	3772.0000	0.3630
10463.3199	6.3210	3772.0000	0.2720
10472.5500	6.4150	4113.0000	0.1800
10468.0699	6.4870	4113.0000	0.0880
10463.5900	6.5490	4113.0000	0.0000
10459.1100	6.6570	4113.0000	-0.0980
10454.6300	6.7400	4113.0000	-0.1900
10450.1500	6.7850	4113.0000	-0.2810
10445.6700	6.8460	4113.0000	-0.3750
10441.1899	6.9490	4113.0000	-0.4680
10436.7100	7.0540	4113.0000	-0.5620
10432.2800	7.3940	4113.0000	-0.6540
10427.8000	7.4470	4113.0000	-0.7500
10423.3199	7.3440	4113.0000	-0.8400
10416.6600	7.7600	4113.0000	-0.7550
10412.2800	7.8650	4113.0000	-0.6600
10407.7000	7.7320	4113.0000	-0.5720
10403.2200	7.9000	4113.0000	-0.4790
10398.7400	8.0100	4113.0000	-0.3860
10394.2600	8.1210	4113.0000	-0.2920
10389.7800	8.1950	4113.0000	-0.1990
10385.3500	8.2960	4113.0000	-0.1060
10380.8199	8.3940	4113.0000	-0.0150
10376.3900	8.5010	4113.0000	0.0800
10370.7700	8.5840	4113.0000	0.1720
10365.1400	8.6970	4113.0000	0.2630
10362.9500	8.7510	4113.0000	0.3580
10286.6300	1.3940	4113.0000	0.4500
10013.6300	9.1770	3810.0000	0.5400
9454.1899	56.1200	3810.0000	0.6300
7973.9400	212.0896	4360.0000	0.7250
5260.6300	360.0577	4360.0000	0.8180
1858.5800	186.8018	1300.0000	0.7080
0.0000	0.0000	0.0000	1.0000

READY

LIST

CASE3 02 SEP 80 15:08

S. J. CORT CASE3
998.0000 41
1.9600
0.0000

3108.4200	1054.0302	820.0000	1.0000	stern
4980.9000	2402.2656	2350.0000	0.9452	
6957.4900	868.4435	2400.0000	0.8355	
9265.9700	81.0149	2380.0000	0.7257	
10325.3101	5.5770	5791.0000	0.6161	
10477.8500	4.6830	5791.0000	0.5071	
10607.2100	2.7610	5791.0000	0.3992	
10719.8300	1.7160	5791.0000	0.2930	
10719.8300	1.7160	5791.0000	0.1893	
10719.8300	1.7160	5791.0000	0.0891	
10719.8300	1.7160	5791.0000	-0.0067	
10719.8300	1.7160	5791.0000	-0.0972	
10719.8300	1.7160	5791.0000	-0.1812	
10719.8300	1.7160	5654.0000	-0.2579	
10719.8300	1.7160	5654.0000	-0.3264	
10719.8300	1.7160	5654.0000	-0.3859	
10719.8300	1.7160	5654.0000	-0.4356	
10719.8300	1.7160	5654.0000	-0.4749	
10719.8300	1.7160	5654.0000	-0.5033	
10719.8300	1.7160	5654.0000	-0.5204	
10719.8300	1.7160	5654.0000	-0.5261	
10719.8300	1.7160	5654.0000	-0.5202	
10719.8300	1.7160	5654.0000	-0.5028	
10719.8300	1.7160	5654.0000	-0.4741	
10719.8300	1.7160	5654.0000	-0.4347	
10719.8300	1.7160	5654.0000	-0.3848	
10719.8300	1.7160	5654.0000	-0.3252	
10719.8300	1.7160	5654.0000	-0.2567	
10719.8300	1.7160	5654.0000	-0.1799	
10719.8300	1.7160	5654.0000	-0.0958	
10719.8300	1.7160	5654.0000	-0.0055	
10719.8300	1.7160	5654.0000	0.0912	
10720.0300	1.7150	5386.0000	0.1903	
10720.2300	1.7140	5386.0000	0.2937	
10667.2700	2.1480	5386.0000	0.3996	
10449.3199	5.4510	5386.0000	0.5072	
9975.5900	28.0782	5386.0000	0.6158	
8569.9000	123.9159	5936.0000	0.7249	
5816.4500	234.7966	5936.0000	0.8348	
2176.0200	93.1999	1300.0000	0.9443	bow
13.6400	33.8528	0.0000	1.0536	

READY

```
LIST

CASE4       02 SEP 80   10:18

S. J. CORT    CASE4
  998.0000    41
    2.0800
    0.0000
 3096.1200   998.4755   820.0000     1.0000
 5047.2700  2205.6653  2350.0000     0.9452
 7102.7800   690.6144  2400.0000     0.8355
 9379.7500    48.4175  2380.0000     0.7257
10404.2400     1.7790  5791.0000     0.6161
10554.0601     1.4810  5791.0000     0.5071
10680.9900     0.6110  5791.0000     0.3992
10791.8500     0.2550  5791.0000     0.2930
10791.8500     0.2550  5791.0000     0.1893
10791.8500     0.2550  5791.0000     0.0891
10791.8500     0.2550  5791.0000    -0.0067
10791.8500     0.2550  5791.0000    -0.0972
10791.8500     0.2550  5791.0000    -0.1812
10791.8500     0.2550  5654.0000    -0.2579
10791.8500     0.2550  5654.0000    -0.3264
10791.8500     0.2550  5654.0000    -0.3859
10791.8500     0.2550  5654.0000    -0.4356
10791.8500     0.2550  5654.0000    -0.474[illegible]
10791.8500     0.2550  5654.0000    -0.5033
10791.8500     0.2550  5654.0000    -0.5204
10791.8500     0.2550  5654.0000    -0.5261
10791.8500     0.2550  5654.0000    -0.5202
10791.8500     0.2550  5654.0000    -0.5028
10791.8500     0.2550  5654.0000    -0.4741
10791.8500     0.2550  5654.0000    -0.4347
10791.8500     0.2550  5654.0000    -0.3848
10791.8500     0.2550  5654.0000    -0.3252
10791.8500     0.2550  5654.0000    -0.2567
10791.8500     0.2550  5654.0000    -0.1799
10791.8500     0.2550  5654.0000    -0.0958
10791.8500     0.2550  5654.0000    -0.0055
10791.8500     0.2550  5654.0000     0.0912
10791.8500     0.2470  5386.0000     0.1903
10791.8400     0.2390  5386.0000     0.2937
10739.7800     0.4720  5386.0000     0.3996
10525.8700     2.0270  5386.0000     0.5072
10062.5601    16.1005  5386.0000     0.6158
 8671.2100    87.3448  5936.0000     0.7249
 5907.9200   178.3923  5936.0000     0.8348
 2122.2400    66.2934  1300.0000     0.9443
   12.9300    34.4547     0.0000     1.0536
READY
```

LIST

CASES 02 SEP 80 11:04

S. J. CORT	CASES		
998.0000	41		
2.0730			
0.0000			
3096.7000	1001.6884	820.0000	1.0000
5043.3600	2216.9408	2350.0000	0.9452
7094.7500	700.3909	2400.0000	0.8355
9373.8199	50.0512	2380.0000	0.7257
10400.1600	1.8980	5791.0000	0.6161
10550.1100	1.5810	5791.0000	0.5071
10677.1600	0.6700	5791.0000	0.3992
10788.1100	0.2830	5791.0000	0.2930
10788.1100	0.2830	5791.0000	0.1893
10788.1100	0.2830	5791.0000	0.0891
10788.1100	0.2830	5791.0000	-0.0067
10788.1100	0.2830	5791.0000	-0.0972
10788.1100	0.2830	5791.0000	-0.1812
10788.1100	0.2830	5654.0000	-0.2579
10788.1100	0.2830	5654.0000	-0.3264
10786.1100	0.2830	5654.0000	-0.3859
10788.1100	0.2830	5654.0000	-0.4356
10788.1100	0.2830	5654.0000	-0.4749
10788.1100	0.2830	5654.0000	-0.5033
10788.1100	0.2830	5654.0000	-0.5204
10788.1100	0.2830	5654.0000	-0.5261
10788.1100	0.2830	5654.0000	-0.5202
10788.1100	0.2830	5654.0000	-0.5028
10788.1100	0.2830	5654.0000	-0.4741
10788.1100	0.2830	5654.0000	-0.4347
10788.1100	0.2830	5654.0000	-0.3848
10788.1100	0.2830	5654.0000	-0.3252
10788.1100	0.2830	5654.0000	-0.2567
10788.1100	0.2830	5654.0000	-0.1799
10788.1100	0.2830	5654.0000	-0.0958
10788.1100	0.2830	5654.0000	-0.0055
10788.1100	0.2830	5654.0000	0.0912
10788.1100	0.2760	5386.0000	0.1903
10788.1100	0.2690	5386.0000	0.2937
10736.0100	0.5170	5386.0000	0.3996
10521.8800	2.3809	5386.0000	0.5072
10058.0100	16.6851	5386.0000	0.6158
8665.8800	89.2469	5936.0000	0.7249
5903.0000	181.4056	5936.0000	0.8348
2218.8700	67.6795	1300.0000	0.9443
12.9600	34.4213	0.0000	1.0536

READY

LIST

CASE6 02 SEP 80 11:57

S. J. CORT CASE6

998.0000	41		
2.0800			
0.0000			
3096.1200	998.4755	820.0000	1.0000
5047.2700	2205.6653	2350.0000	0.9452
7102.7800	690.6144	2400.0000	0.8355
9379.7500	48.4175	2380.0000	0.7257
10404.2400	1.7790	5791.0000	0.6161
10554.0601	1.4810	5791.0000	0.5071
10680.9900	0.6110	5791.0000	0.3992
10791.8500	0.2550	5791.0000	0.2930
10791.8500	0.2550	5791.0000	0.1893
10791.8500	0.2550	5791.0000	0.0891
10791.8500	0.2550	5791.0000	-0.0067
10791.8500	0.2550	5791.0000	-0.0972
10791.8500	0.2550	5791.0000	-0.1812
10791.8500	0.2550	5654.0000	-0.2579
10791.8500	0.2550	5654.0000	-0.3264
10791.8500	0.2550	5654.0000	-0.3859
10791.8500	0.2550	5654.0000	-0.4356
10791.8500	0.2550	5654.0000	-0.4749
10791.8500	0.2550	5654.0000	-0.5033
10791.8500	0.2550	5654.0000	-0.5204
10791.8500	0.2550	5654.0000	-0.5261
10791.8500	0.2550	5654.0000	-0.5202
10791.8500	0.2550	5654.0000	-0.5028
10791.8500	0.2550	5654.0000	-0.4741
10791.8500	0.2550	5654.0000	-0.4347
10791.8500	0.2550	5654.0000	-0.3848
10791.8500	0.2550	5654.0000	-0.3252
10791.8500	0.2550	5654.0000	-0.2567
10791.8500	0.2550	5654.0000	-0.1799
10791.8500	0.2550	5654.0000	-0.0958
10791.8500	0.2550	5654.0000	-0.0055
10791.8500	0.2550	5654.0000	0.0912
10791.8500	0.2470	5386.0000	0.1903
10791.8400	0.2390	5386.0000	0.2937
10739.7800	0.4720	5386.0000	0.3996
10525.8700	2.0270	5386.0000	0.5072
10062.5601	16.1005	5386.0000	0.6158
8671.2100	87.3448	5936.0000	0.7249
5907.9200	178.3923	5936.0000	0.8348
2122.2400	66.2934	1300.0000	0.9443
12.9300	34.4547	0.0000	1.0536

READY

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LIST

CASE7      29 DEC 80  14:22

S. J. CORT    CASE7
  998.0000    41
    2.2050
    0.0000
 2840.8500   324.5150   820.0000    1.0000
 6064.6400  2321.7050  2350.0000    0.9280
 8694.8600   182.1530  2400.0000    0.8160
 9950.9700     7.1980  2380.0000    0.7400
10111.7000     5.2650  3772.0000    0.6240
10111.7000     5.2650  3772.0000    0.5530
10260.9700     1.8990  3772.0000    0.4590
10397.6500     8.1030  3772.0000    0.3630
10390.2300     8.1930  3772.0000    0.2720
10382.8500     8.3530  4113.0000    0.1000
10375.4900     8.4940  4113.0000    0.0880
10368.0800     8.6100  4113.0000    0.0000
10360.4700     8.8080  4113.0000   -0.0980
10353.0900     8.9440  4113.0000   -0.1900
10345.4900     9.1380  4113.0000   -0.2810
10338.1100     9.2590  4113.0000   -0.3750
10330.5000     9.4330  4113.0000   -0.4680
10322.6700     9.5990  4113.0000   -0.5620
10315.0601     9.8190  4113.0000   -0.6540
10307.3300    10.0390  4113.0000   -0.7500
10299.6300    10.2360  4113.0000   -0.8400
10291.8101    10.4480  4113.0000   -0.7550
10284.2000    10.6450  4113.0000   -0.6600
10276.6899    10.8488  4113.0000   -0.5720
10268.8101    11.0590  4113.0000   -0.4790
10261.2300    11.2520  4113.0000   -0.3860
10253.7800    11.4860  4113.0000   -0.2920
10245.7300    11.7130  4113.0000   -0.1990
10237.9000    11.9600  4113.0000   -0.1060
10229.8500    12.1970  4113.0000   -0.0150
10222.3400    12.4390  4113.0000    0.0800
10214.1899    12.6980  4113.0000    0.1720
10206.2300    12.9640  4113.0000    0.2630
10198.5400    13.1610  4113.0000    0.3580
10133.2600    13.4840  4113.0000    0.4500
 9828.1300    18.2740  3810.0000    0.5400
 9243.5900    89.6140  3810.0000    0.6300
 7728.1500   294.6100  4360.0000    0.7250
 5043.8000   471.5780  4360.0000    0.8180
 1748.0400   240.2810  1300.0000    0.9080
    0.0000     0.0000     0.0000    1.0000
READY
```

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LIST
CASE8        18 DEC 80   14:33

S. J. CORT    CASE8
   998.0000   41
     2.2050
     0.0000
   825.3600 1038.6020  820.0000     1.0000
  6225.2600 2019.9070 2350.0000     0.9280
  8825.3000  123.4490 2400.0000     0.8160
 10034.2300    4.8670 2380.0000     0.7400
 10034.2300    4.8670 3772.0000     0.6240
 10193.2800    3.7870 3772.0000     0.5530
 10338.1000    1.3280 3772.0000     0.4590
 10482.3800    6.2240 3772.0000     0.3630
 10477.6899    6.3210 3772.0000     0.2720
 10473.2100    6.4140 4113.0000     0.1800
 10468.7400    6.4880 4113.0000     0.0880
 10464.2700    6.5490 4113.0000     0.0000
 10459.6300    6.6580 4113.0000    -0.0980
 10455.0900    6.7390 4113.0000    -0.1900
 10450.3900    6.7840 4113.0000    -0.2810
 10446.0100    6.8460 4113.0000    -0.3750
 10441.2700    6.9460 4113.0000    -0.4680
 10436.7500    7.0540 4113.0000    -0.5620
 10431.2500    7.3940 4113.0000    -0.6540
 10426.9100    7.4470 4113.0000    -0.7500
 10422.6600    7.3450 4113.0000    -0.8400
 10417.0699    7.7600 4113.0000    -0.7550
 10412.3700    7.8660 4113.0000    -0.6600
 10408.5699    7.7320 4113.0000    -0.5720
 10403.8900    7.8990 4113.0000    -0.4790
 10399.4000    8.0110 4113.0000    -0.3860
 10394.5699    8.1210 4113.0000    -0.2920
 10390.0000    8.1940 4113.0000    -0.1990
 10385.3000    8.2950 4113.0000    -0.1060
 10380.3800    8.3950 4113.0000    -0.0150
 10375.7300    8.5000 4113.0000     0.0800
 10370.8500    7.9310 4113.0000     0.1720
 10366.0601    8.6970 4113.0000     0.2630
 10361.8199    8.7520 4113.0000     0.3580
 10287.1200    1.3950 4113.0000     0.4500
 10013.2200    9.1790 3810.0000     0.5400
  9453.5200   56.1380 3810.0000     0.6300
  7973.0100  211.8300 4360.0000     0.7250
  5259.5400  359.7990 4360.0000     0.8180
  1858.9400  186.6540 1300.0000     0.9080
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READY
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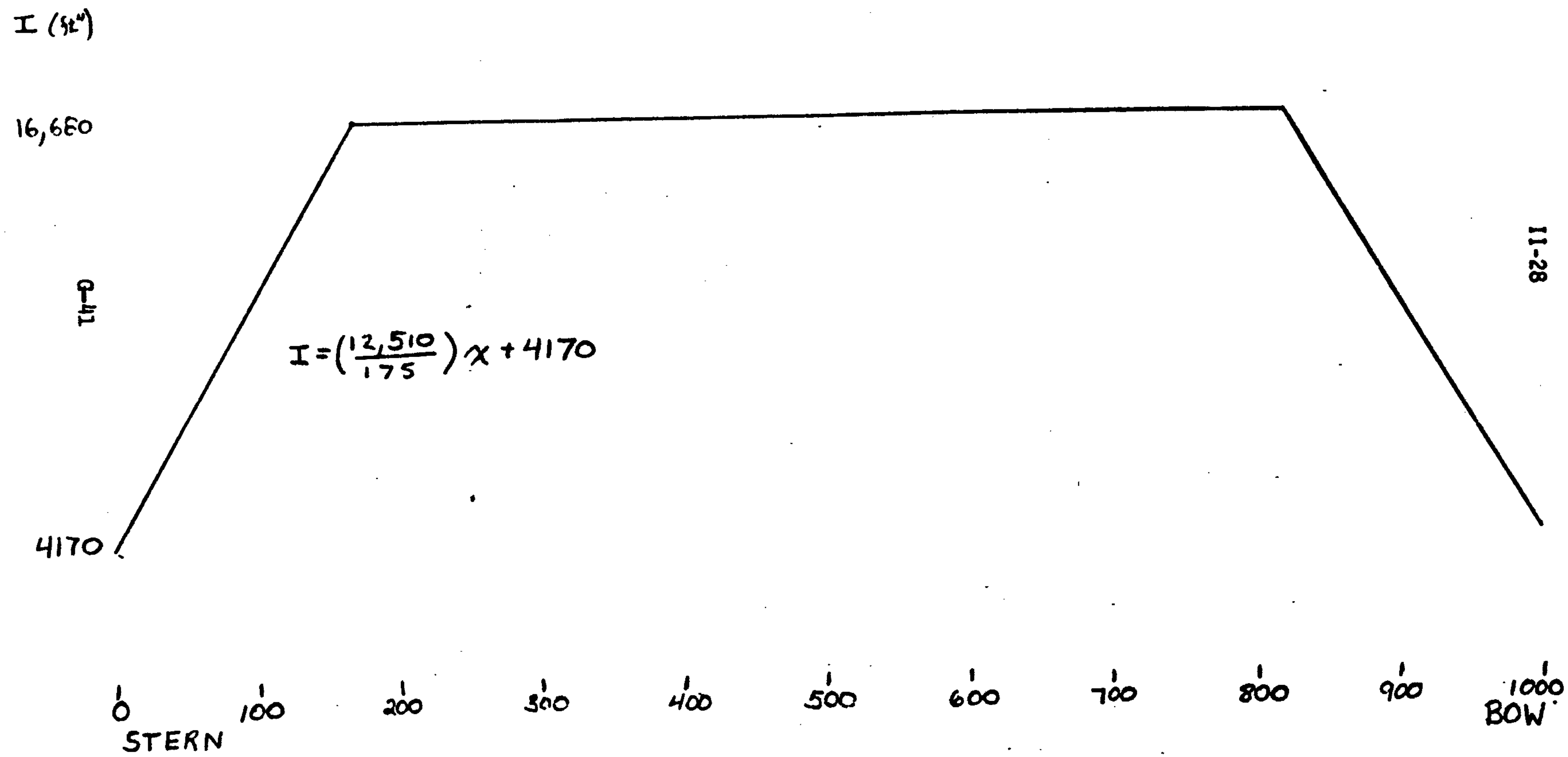
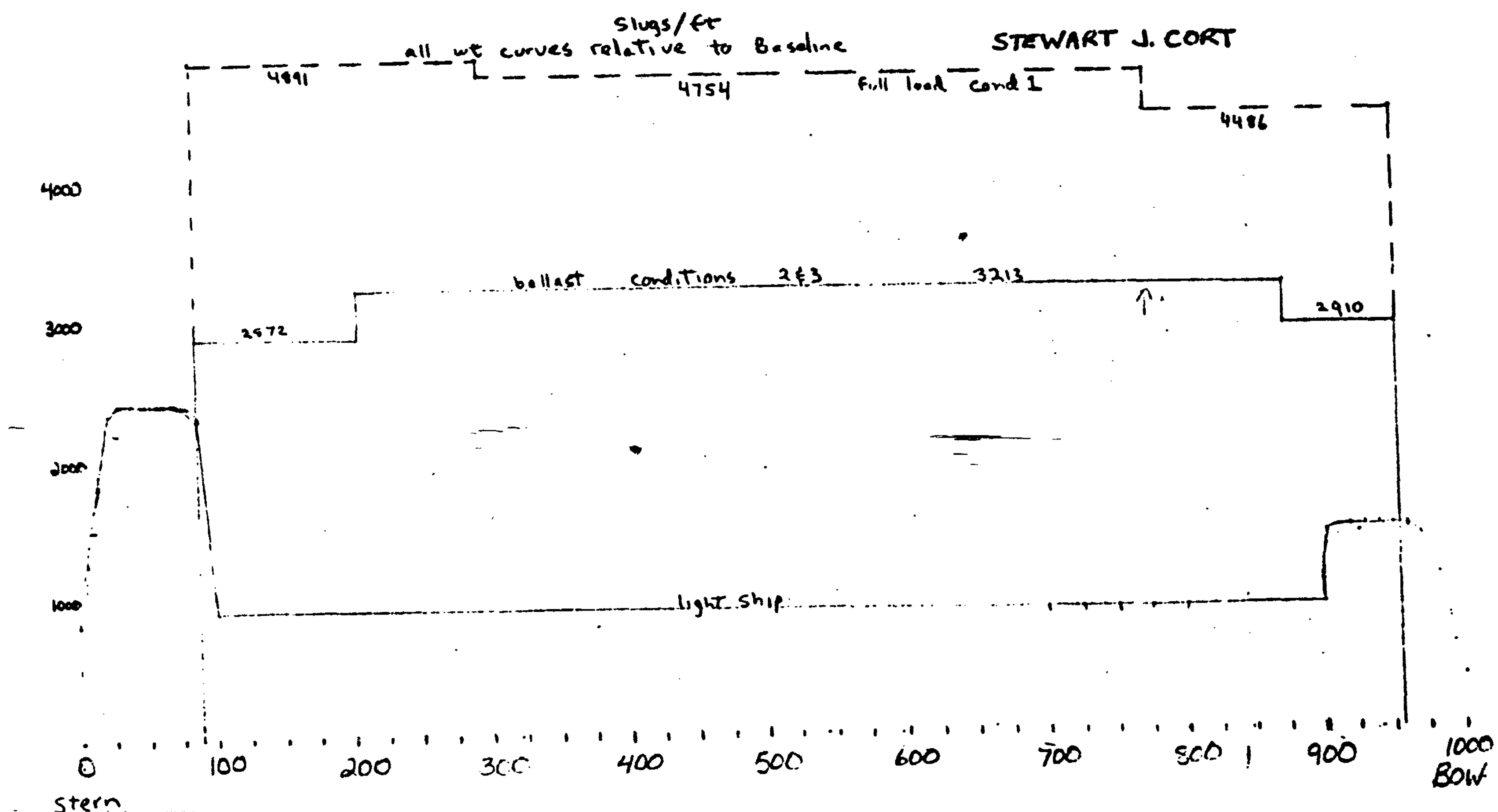
Assumed Distribution of Transverse
Moment of Inertia



G-41



Assumed Weight Distribution

APPENDIX III

RESULTS OF CALCULATIONS

SPM2G163 18 DEC 80 13:52 III-1

```
SHIP DATA FILE NAME? CASE1
OFFSET DATA FILE NAME? OFCOR3
SPEED? 21.12021.120
FREQ.? 1.50503.0050.1
HEADING? 174.
```

SPM2Z S. J. CORT CASE1 12/18/80 13:53:06 PAGE 1

SHIP/EFF. WAVE LENGTH	(NON-D.)	4.289	4.707	5.133
EFFECTIVE WAVE LENGTH	(FEET)	232.675	212.026	194.428
ENCOUNTER FREQUENCY	(1/SEC.)	1.505	1.605	1.705
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	21.120	21.120	21.120
WAVE HEADING	(DEG.)	174.000	174.000	174.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-4.5115E+03	-4.5115E+03	-4.5115E+03
TOTAL ADDED MASS	(SLUGS)	3.3086E+06	3.3086E+06	3.3086E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.1702E+04	7.1702E+04	7.1702E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	1.7432E+04	1.7432E+04	1.7432E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING	(SLUGS/SEC)	1.0432E+05	1.0432E+05	1.0432E+05
DAMPING/ADDED MASS	(1/SEC.)	0.032	0.032	0.032
PHI-FORCE & MOTION	(RAD.)	0.018	0.022	0.027
MAGNIFICATION FACTOR	(NON-D.)	1.8719E+00	2.1263E+00	2.4860E+00
F COS(EPS)	(LBS.)	2.6002E+04	-1.5563E+05	-7.7865E+04
F SIN(EPS)	(LBS.)	2.5464E+04	1.6981E+05	9.7726E+04
F-WAVE EXCITING FORCE	(LBS.)	3.6394E+04	2.2899E+05	1.2495E+05
EPS-FORCE & WAVE	(RAD.)	0.775	2.306	2.244
DEFLECTION AT STERN	(FEET)	4.2349E-03	3.0269E-02	1.9311E-02
EPS1-WAVE & VIBRATION	(RAD.)	-0.757	-2.284	-2.216
M COS(EPS2)	(LBS.)	2.9851E+06	-2.1205E+07	-1.2975E+07
M SIN(EPS2)	(LBS.)	-2.6253E+06	-2.6109E+07	-1.9435E+07
M-BENDING MOMENT AMID	(LBS.)	3.9753E+06	3.3635E+07	2.3368E+07
EPS2-WAVE & B.M.	(RAD.)	5.562	4.030	4.124

SHIP/EFF. WAVE LENGTH	(NON-D.)	5.567	6.008	6.455
EFFECTIVE WAVE LENGTH	(FEET)	179.279	166.120	154.600
ENCOUNTER FREQUENCY	(1/SEC.)	1.805	1.905	2.005
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	21.120	21.120	21.120
WAVE HEADING	(DEG.)	174.000	174.000	174.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-4.5115E+03	-4.5115E+03	-4.5115E+03
TOTAL ADDED MASS	(SLUGS)	3.3086E+06	3.3086E+06	3.3086E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.1702E+04	7.1702E+04	7.1702E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	1.7432E+04	1.7432E+04	1.7432E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING	(SLUGS/SEC)	1.0432E+05	1.0432E+05	1.0432E+05
DAMPING/ADDED MASS	(1/SEC.)	0.032	0.032	0.032
PHI-FORCE & MOTION	(RAD.)	0.035	0.049	0.075
MAGNIFICATION FACTOR	(NON-D.)	3.0293E+00	3.9386E+00	5.7582E+00
F COS(EPS)	(LBS.)	1.4515E+05	1.5987E+05	-6.0758E+04
F SIN(EPS)	(LBS.)	-1.0846E+05	-1.6534E+05	1.1800E+04
F-WAVE EXCITING FORCE	(LBS.)	1.8120E+05	2.3000E+05	6.1908E+04
EPS-FORCE & WAVE	(RAD.)	5.641	5.481	2.949
DEFLECTION AT STERN	(FEET)	3.4122E-02	5.6312E-02	2.2160E-02
EPS1-WAVE & VIBRATION	(RAD.)	-5.606	-5.432	-2.874
M COS(EPS2)	(LBS.)	3.8719E+07	5.7772E+07	-3.9940E+07
M SIN(EPS2)	(LBS.)	3.3894E+07	6.9552E+07	-1.4129E+07
M-BENDING MOMENT AMID	(LBS.)	5.1459E+07	9.0416E+07	4.2365E+07
EPS2-WAVE & B.M.	(RAD.)	0.719	0.878	3.482

SHIP/EFF. WAVE LENGTH	(NON-D.)	6.909	7.369	7.835
EFFECTIVE WAVE LENGTH	(FEET)	144.442	135.427	127.381
ENCOUNTER FREQUENCY	(1/SEC.)	2.105	2.205	2.305
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	21.120	21.120	21.120
WAVE HEADING	(DEG.)	174.000	174.000	174.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-4.5115E+03	-4.5115E+03	-4.5115E+03
TOTAL ADDED MASS	(SLUGS)	3.3086E+06	3.3086E+06	3.3086E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.1702E+04	7.1702E+04	7.1702E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	1.7432E+04	1.7432E+04	1.7432E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING	(SLUGS/SEC)	1.0432E+05	1.0432E+05	1.0432E+05
DAMPING/ADDED MASS	(1/SEC.)	0.032	0.032	0.032
PHI-FORCE & MOTION	(RAD.)	0.153	1.571	2.982
MAGNIFICATION FACTOR	(NON-D.)	1.1149E+01	6.9936E+01	1.0643E+01
F COS(EPS)	(LBS.)	-1.5454E+05	3.0321E+04	1.7449E+05
F SIN(EPS)	(LBS.)	1.6423E+05	6.7008E+04	-1.2087E+05
F-WAVE EXCITING FORCE	(LBS.)	2.2550E+05	7.3549E+04	2.1227E+05
EPS-FORCE & WAVE	(RAD.)	2.326	1.146	5.677
DEFLECTION AT STERN	(FEET)	1.5630E-01	3.1976E-01	1.4044E-01
EPS1-WAVE & VIBRATION	(RAD.)	-2.173	0.425	-2.696
M COS(EPS2(	(LBS.)	-1.7439E+08	6.5786E+08	-2.9955E+08
M SIN(EPS2)	(LBS.)	-2.6665E+08	3.5590E+08	-1.7157E+08
M-BENDING MOMENT AMID	(LBS.)	3.1861E+08	7.4796E+08	3.4521E+08
EPS2-WAVE & B.M.	(RAD.)	4.133	0.496	3.662

SHIP/EFF. WAVE LENGTH	(NON-D.)	8.306	8.781	9.262
EFFECTIVE WAVE LENGTH	(FEET)	120.160	113.650	107.753
ENCOUNTER FREQUENCY	(1/SEC.)	2.405	2.505	2.605
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	21.120	21.120	21.120
WAVE HEADING	(DEG.)	174.000	174.000	174.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-4.5115E+03	-4.5115E+03	-4.5115E+03
TOTAL ADDED MASS	(SLUGS)	3.3086E+06	3.3086E+06	3.3086E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.1702E+04	7.1702E+04	7.1702E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	1.7432E+04	1.7432E+04	1.7432E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING	(SLUGS/SEC)	1.0432E+05	1.0432E+05	1.0432E+05
DAMPING/ADDED MASS	(1/SEC.)	0.032	0.032	0.032
PHI-FORCE & MOTION	(RAD.)	3.060	3.086	3.099
MAGNIFICATION FACTOR	(NON-D.)	5.2556E+00	3.4356E+00	2.5247E+00
F COS(EPS)	(LBS.)	3.6503E+04	-1.3286E+05	-4.5807E+04
F SIN(EPS)	(LBS.)	-1.0707E+05	6.6640E+04	1.1002E+05
F-WAVE EXCITING FORCE	(LBS.)	1.1312E+05	1.4863E+05	1.1917E+05
EPS-FORCE & WAVE	(RAD.)	5.041	2.677	1.965
DEFLECTION AT STERN	(FEET)	3.6958E-02	3.1743E-02	1.8704E-02
EPS1-WAVE & VIBRATION	(RAD.)	-1.981	0.409	1.134
M COS(EPS2)	(LBS.)	-3.6257E+07	8.3495E+07	2.3185E+07
M SIN(EPS2)	(LBS.)	-9.7518E+07	4.1977E+07	5.7498E+07
M-BENDING MOMENT AMID	(LBS.)	1.0404E+08	9.3453E+07	6.1996E+07
EPS2-WAVE & B.M.	(RAD.)	4.356	0.466	1.188

SHIP/EFF. WAVE LENGTH	(NON-D.)	9.747	10.236	10.730
EFFECTIVE WAVE LENGTH	(FEET)	102.391	97.496	93.013
ENCOUNTDR FREQUENCY	(1/SEC.)	2.705	2.805	2.905
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	21.120	21.120	21.120
WAVE HEADING	(DEG.)	174.000	174.000	174.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-4.5115E+03	-4.5115E+03	-4.5115E+03
TOTAL ADDED MASS	(SLUGS)	3.3086E+06	3.3086E+06	3.3086E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.1702E+04	7.1702E+04	7.1702E+04
PEED DEPENDENT DAMP:	(SLUGS/SEC)	1.7432E+04	1.7432E+04	1.7432E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING	(SLUGS/SEC)	1.0432E+05	1.0432E+05	1.0432E+05
DAMPING/ADDED MASS	(1/SEC.)	0.032	0.032	0.032
PHI-FORCE & MOTION	(RAD.)	3.107	3.112	3.116
MAGNIFICATION FACTOR	(NON-D.)	1.9793E+00	1.6167E+00	1.3508E+00
F COS(EPS)	(LBS.)	1.1872E+05	6.8538E+04	-7.3891E+04
F SIN(EPS)	(LBS.)	-2.4660E+04	-9.0521E+04	4.1871E+03
F-WAVE EXCITING FORCE	(LBS.)	1.2125E+05	1.1354E+05	7.4010E+04
EPS-FORCE & WAVE	(RAD.)	6.078	5.360	3.085
DEFLECTION AT STERN	(FEET)	1.4919E-02	1.1411E-02	6.2515E-03
EPS1-WAVE & VIBRATION	(RAD.)	-2.972	-2.248	0.031
M COS(EPS2)	(LBS.)	-5.0765E+07	-2.5678E+07	2.5416E+07
M SIN(EPS2)	(LBS.)	-1.0961E+07	-3.5562E+07	1.7149E+06
M-BENDING MOMENT AMID	(LBS.)	5.1935E+07	4.3864E+07	2.5474E+07
EPS2-WAVE & B.M.	(RAD.)	3.354	4.087	0.067

SHIP/EFF. WAVE LENGTH	(NON-D.)	11.227
EFFECTIVE WAVE LENGTH	(FEET)	88.893
ENCOUNTER FREQUENCY	(1/SEC.)	3.005
RESONANT FREQUENCY	(1/SEC.)	2.205
SPEED	(FT/SEC)	21.120
WAVE HEADING	(DEG.)	174.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3593E+06
SHIP MASS	(SLUGS)	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-4.5115E+03
TOTAL ADDED MASS	(SLUGS)	3.3086E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.1702E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	1.7432E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5182E+04
TOTAL DAMPING	(SLUGS/SEC)	1.0432E+05
DAMPING/ADDED MASS	(1/SEC.)	0.032
PHI-FORCE & MOTION	(RAD.	3.119
MAGNIFICATION FACTOR	(NON-D..	1.1662E+00
F COS(EPS)	(LBS.)	-4.4508E+04
F SIN(EPS)	(LBS.)	6.5763E+04
F-WAVE EXCITING FORCE	(LBS.)	7.9409E+04
EPS-FORCE & WAVE	(RAD.)	2.166
DEFLECTION AT STERN	(FEET)	5.7569E-03
EPS1-WAVE & VIBRATION	(RAD.)	0.953
M COS(EPS2)	(LBS.)	1.3828E+07
M SIN(EPS2)	(LBS.)	2.1449E+07
M--BENDING MOMENT AMID	(LBS.)	2.5520E+07
EPS2-WAVE & B.M.	(RAD.)	0.998

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SHIP DATA FILE NAME? CASE2
OFFSET DATA FILE NAME? OFCOR3
SPEED? 21.12021.120
FREQ.? 1.50502.9050.1
HEADING? 169.
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SHIP/EFF. WAVE LENGTH	(NON-D.)	4.264	4.680	5.104
EFFECTIVE WAVE LENGTH	(FEET)	234.051	213.247	195.521
ENCOUNTER FREQUENCY	(1/SEC.)	1.505	1.605	1.705
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	21.120	21.120	21.120
WAVE HEADING	(DEG.)	169.000	169.000	169.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-4.5115E+03	-4.5115E+03	-4.5115E+03
TOTAL ADDED MASS	(SLUGS)	3.3086E+06	3.3086E+06	3.3086E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.1705E+04	7.1705E+04	7.1705E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	1.7432E+04	1.7432E+04	1.7432E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING	(SLUGS/SEC)	1.0432E+05	1.0432E+05	1.0432E+05
DAMPING/ADDED MASS	(1/SEC.)	0.032	0.032	0.032
PHI-FORCE & MOTION	(RAD)	0.018	0.022	0.027
MAGNIFICATION FACTOR	(NON-D.)	1.8719E+00	2.1263E+00	2.4860E+00
F COS(EPS)	(LBS.)	3.8603E+04	-1.5172E+05	-9.1489E+04
F SIN(EPS)	(LBS.)	1.2601E+04	1.6693E+05	1.1096E+05
F-WAVE EXCITING FORCE	(LBS.)	4.0608E+04	2.2557E+05	1.4381E+05
EPS-FORCE & WAVE	(RAD.)	0.316	2.308	2.260
DEFLECTION AT STERN	(FEET)	4.7252E-03	2.9817E-02	2.2225E-02
EPS1-WAVE & VIBRATION	(RAD.)	-0.297	-2.286	-2.233
M COS(EPS2)	(LBS.)	4.1993E+06	-2.1037E+07	-1.5456E+07
M SIN(EPS2)	(LBS.)	-1.1112E+06	-2.5803E+07	-2.2070E+07
M-BENDING MOMENT AMID	(LBS.)	4.3439E+06	3.3292E+07	2.6943E+07
EPS2-WAVE & B.M.	(RAD.)	6.024	4.028	4.181

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SHIP/EFF. WAVE LENGTH	(NON-D.)	5.536	5.976	6.422
EFFECTIVE WAVE LENGTH	(FEET)	180.263	167.012	155.412
ENCOUNTER FREQUENCY	(1/SEC.)	1.805	1.905	2.005
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	21.120	21.120	21.120
WAVE HEADING	(DEG.)	169.000	169.000	169.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-4.5115E+03	-4.5115E+03	-4.5115E+03
TOTAL ADDED MASS	(SLUGS)	3.3086E+06	3.3086E+06	3.3086E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.1705E+04	7.1705E+04	7.1705E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	1.7432E+04	1.7432E+04	1.7432E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING	(SLUGS/SEC)	1.0432E+05	1.0432E+05	1.0432E+05
DAMPING/ADDED MASS	(1/SEC.)	0.032	0.032	0.032
PHI-FORCE & MOTION	(RAD.)	0.035	0.049	0.075
MAGNIFICATION FACTOR	(NON-D.)	3.0293E+00	3.9386E+00	5.7582E+00
F COS(EPS)	(LBS.)	1.3645E+05	1.7186E+05	-4.5503E+04
F SIN(EPS)	(LBS.)	-9.5586E+04	-1.7176E+05	-6.0519E+03
F-WAVE EXCITING FORCE	(LBS.)	1.6650E+05	2.4298E+05	4.5904E+04
EPS-FORCE & WAVE	(RAD.)	5.672	5.498	3.274
DEFLECTION AT STERN	(FEET)	3.1373E-02	5.9490E-02	1.6431E-02
EPS1-WAVE & VIBRATION	(RAD.)	-5.637	-5.449	-3.199
M COS(EPS2)	(LBS.)	3.6537E+07	6.2771E+07	-3.1182E+07
M SIN(EPS2)	(LBS.)	3.0336E+07	7.2558E+07	-9.2091E+05
M-BENDING MOMENT AMID	(LBS.)	4.7489E+07	9.5941E+07	3.1195E+07
EPS2-WAVE & B.M.	(RAD.)	0.693	0.858	3.171

SHIP/EFF. WAVE LENGTH(NON-D.)	6.874	7.332	7.796
EFFECTIVE WAVE LENGTH(FEET)	145.185	136.111	128.011
ENCOUNTER FREQUENCY (1/SEC.)	2.105	2.205	2.305
RESONANT FREQUENCY (1/SEC.)	2.205	2.205	2.205
SPEED (FT/SEC)	21.120	21.120	21.120
WAVE HEADING (DEG.)	169.000	169.000	169.000
HYDRODYNAMIC A.M. (SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS (SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M. (SLUGS)	-4.5115E+03	-4.5115E+03	-4.5115E+03
TOTAL ADDED MASS (SLUGS)	3.3086E+06	3.3086E+06	3.3086E+06
HYDRODYNAMIC DAMPING (SLUGS/SEC)	7.1705E+04	7.1705E+04	7.1705E+04
SPEED DEPENDENT DAMP.(SLUGS/SEC)	1.7432E+04	1.7432E+04	1.7432E+04
STRUCTURAL DAMPING (SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING (SLUGS/SEC)	1.0432E+05	1.0432E+05	1.0432E+05
DAMPING/ADDED MASS (1/SEC.)	0.032	0.032	0.032
PHI-FORCE & MOTION (RAD.)	0.153	1.571	2.982
MAGNIFICATION FACTOR (NON-D.)	1.1149E+01	6.9933E+01	1.0643E+01
F COS(EPS) (LBS.)	-1.6124E+05	1.2082E+04	1.7594E+05
F SIN(EPS) (LBS.)	1.6117E+05	8.4000E+04	-1.1008E+05
F-WAVE EXCITING FORCE(LBS.)	2.2798E+05	8.4864E+04	2.0754E+05
EPS-FORCE & WAVE (RAD.)	2.356	1.428	5.724
DEFLECTION AT STERN (FEET)	1.5801E-01	3.6894E-01	1.3732E-01
EPS1-WAVE & VIBRATION(RAD.)	-2.204	0.143	-2.742
M COS(EPS2) (LBS.)	-1.8567E+08	8.3490E+08	-2.9974E+08
M SIN(EPS2) (LBS.)	-2.6517E+08	1.8994E+08	-1.5236E+08
M-BENDING MOMENT AMID(LBS.)	3.2372E+08	8.5624E+08	3.3624E+08
EPS2-WAVE & B.M. (RAD.)	4.102	0.224	3.612

SHIP/EFF. WAVE LENGTH(NON-D.)	8.265	8.740	9.219
EFFECTIVE WAVE LENGTH(FEET)	120.744	114.193	108.259
ENCOUNTER FREQUENCY (1/SEC.)	2.405	2.505	2.605
RESONANT FREQUENCY (1/SEC.)	2.205	2.205	2.205
SPEED (FT/SEC)	21.120	21.120	21.120
WAVE HEADING (DEG.)	169.000	169.000	169.000
HYDRODYNAMIC A.M. (SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS (SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M. (SLUGS)	-4.5115E+03	-4.5115E+03	-4.5115E+03
TOTAL ADDED MASS (SLUGS)	3.3086E+06	3.3086E+06	3.3086E+06
HYDRODYNAMIC DAMPING (SLUGS/SEC)	7.1705E+04	7.1705E+04	7.1705E+04
SPEED DEPENDENT DAMP.(SLUGS/SEC)	1.7432E+04	1.7432E+04	1.7432E+04
STRUCTURAL DAMPING (SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING (SLUGS/SEC)	1.0432E+05	1.0432E+05	1.0432E+05
DAMPING/ADDED MASS (1/SEC.)	0.032	0.032	0.032
PHI-FORCE & MOTION (RAD.)	3.060	3.086	3.099
MAGNIFICATION FACTOR (NON-D.)	5.2556E+00	3.4356E+00	2.5247E+00
F COS(EPS) (LBS.)	5.5783E+04	-1.2901E+05	-6.3284E+04
F SIN(EPS) (LBS.)	-1.1922E+05	5.1978E+04	1.1643E+05
F-WAVE EXCITING FORCE(LBS.)	1.3163E+05	1.3909E+05	1.3252E+05
EPS-FORCE & WAVE (RAD.)	5.150	2.759	2.069
DEFLECTION AT STERN (FEET)	4.3004E-02	2.9706E-02	2.0799E-02
EPS1-WAVE & VIBRATION(RAD.)	-2.090	0.327	1.030
M COS(EPS2) (LBS.)	-5.3615E+07	8.1059E+07	3.1943E+07
M SIN(EPS2) (LBS.)	-1.0836E+08	3.2350E+07	6.0921E+07
M-BENDING MOMENT AMID(LBS.)	1.2090E+08	8.7276E+07	6.8787E+07
EPS2-WAVE & B.M. (RAD.)	4.253	0.380	1.088

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SHIP/EFF. WAVE LENGTH	(NON-D.)	9.702	10.190	10.682
EFFECTIVE WAVE LENGTH	(FEET)	102.864	97.940	93.429
ENCOUNTER FREQUENCY	(1/SEC.)	2.705	2.805	2.905
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	21.120	21.120	21.120
WAVE HEADING	(DEG.)	169.000	169.000	169.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-4.5115E+03	-4.5115E+03	-4.5115E+03
TOTAL ADDED MASS	(SLUGS)	3.3086E+06	3.3086E+06	3.3086E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.1705E+04	7.1705E+04	7.1705E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	1.7432E+04	1.7432E+04	1.7432E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING	(SLUGS/SEC)	1.0432E+05	1.0432E+05	1.0432E+05
DAMPING/ADDED MASS	(1/SEC.)	0.032	0.032	0.032
PHI-FORCE & MOTION	(RAD.)	3.107	3.112	3.116
MAGNIFICATION FACTOR	(NON-D.)	1.9793E+00	1.6167E+00	1.3588E+00
F COS(EPS)	(LBS.)	1.1188E+05	8.3304E+04	-6.6206E+04
F SIN(EPS)	(LBS.)	-9.9136E+03	-9.2679E+04	-8.3578E+03
F-WAVE EXCITING FORCE	(LBS.)	1.1232E+05	1.2462E+05	6.6732E+04
EPS-FORCE & WAVE	(RAD.)	6.195	5.445	3.267
DEFLECTION AT STERN	(FEET)	1.3820E-02	1.2524E-02	5.6368E-03
EPS1-WAVE & VIBRATION	(RAD.)	-3.088	-2.332	-0.151
M COS(EPS2)	(LBS.)	-4.7923E+07	-3.1229E+07	2.2844E+07
M SIN(EPS2)	(LBS.)	-4.4302E+06	-3.6483E+07	-2.7042E+06
M-BENDING MOMENT AMID	(LBS.)	4.8127E+07	4.8024E+07	2.3004E+07
EPS2-WAVE & B.M.	(RAD.)	3.234	4.004	6.165

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SHIP/EFF. WAVE LENGTH	(NON-D.)	0.926	1.208	1.511
EFFECTIVE WAVE LENGTH	(FEET)	1077.685	826.149	660.291
ENCOUNTER FREQUENCY	(1/SEC.)	0.560	0 660	0.760
RESONANT FREQUENCY	(1/SEC.)	1.960	1.960	1.960
SPEED	(FT/SEC)	21.560	21.560	21.560
WAVE HEADING	(DEG.)	174.000	174.000	174.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9074E+06	1.9074E+06	1.9074E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.8596E+03	-2.8596E+03	-2.8596E+03
TOTAL ADDED MASS	(SLUGS)	2.9162E+06	2.9162E+06	2.9162E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	9.0365E+04	9.0365E+04	9.0365E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.8269E+04	4.8269E+04	4.8269E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.0930E+04	1.0930E+04	1.0930E+04
TOTAL DAMPING	(SLUGS/SEC)	1.4956E+05	1.4956E+05	1.4956E+05
DAMPING/ADDED MASS	(1/SEC.)	0.051	0.051	0.051
PHI-FORCE & MOTION	(RAD.)	0.008	0.010	0.012
MAGNIFICATION FACTOR	(NON-D.)	1.0889E+00	1.1278E+00	1.1769E+00
F COS(EPS)	(LBS.)	-1.2662E+06	-1.1186E+06	-5.4541E+05
F SIN(EPS)	(LBS.)	-9.7653E+04	-2.3893E+04	6.4672E+04
F-WAVE EXCITING FORCE	(LBS.)	1.2700E+06	1.1189E+06	5.4923E+05
EPS-FORCE & WAVE	(RAD.)	3.219	3.163	3.024
DEFLECTION AT STERN	(FEET)	1.2343E-01	1.1264E-01	5.7697E-02
EPS1-WAVE & VIBRATION	(RAD.)	-3.210	-3.153	-3.012
M COS(EPS2)	(LBS.)	-5.9442E+06	-2.115+7	-9.2334E+06
M SIN(EPS2)	(LBS.)	-4.6237E+07	-1.4286E+07	3.8719E+06
M-BENDING MOMENT AMID	(LBS.)	4.6618E+07	2.5525E+07	1.0012E+07
EPS2-WAVE & B.M.	(RAD.)	4.585	3.736	2.745

SHIP/EFF. WAVE LENGTH	(NON-D.)	1.834	2.172	2.525
EFFECTIVE WAVE LENGTH	(FEET)	544.286	459.441	395.175
ENCOUNTER FREQUENCY	(1/SEC.)	0.860	0.960	1.060
RESONANT FREQUENCY	(1/SEC.)	1.960	1.960	1.960
SPEED	(FT/SEC)	21.560	21.560	21.560
WAVE HEADING	(DEG.)	174.000	174.000	174.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9074E+06	1.9074E+06	1.9074E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.8596E+03	-2.8596E+03	-2.8596E+03
TOTAL ADDED MASS	(SLUGS)	2.9162E+06	2.9162E+06	2.9162E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	9.0365E+04	9.0365E+04	9.0365E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.8269E+04	4.8269E+04	4.8269E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.0930E+04	1.0930E+04	1.0930E+04
TOTAL DAMPING	(SLUGS/SEC)	1.4956E+05	1.4956E+05	1.4956E+05
DAMPING/ADDED MASS	(1/SEC.)	0.051	0.051	0.051
PHI-FORCE & MOTION	(RAD.)	0.014	0.017	0.020
MAGNIFICATION FACTOR	(NON-D.)	1.2383E+00	1.3154E+00	1.4131E+00
F COS(EPS)	(LBS.)	7.3126E+04	3.1219E+05	1.0511E+05
F SIN(EPS)	(LBS.)	1.0932E+05	7.3250E+04	-1.8157E+04
F-WAVE EXCITING FORCE	(LBS.)	1.3152E+05	3.2067E+05	1.0666E+05
EPS-FORCE & WAVE	(RAD.)	0.981	0.230	6.112
DEFLECTION AT STERN	(FEET)	1.4538E-02	3.7652E-02	1.3454E-02
EPS1-WAVE & VIBRATION	(RAD.)	-0.967	-0.214	-6.092
M COS(EPS2)	(LBS.)	6.8157E+05	8.9855E+06	3.8365E+06
M SIN(EPS2)	(LBS.)	1.1062E+06	6.2513E+05	-1.8319E+03
M-BENDING MOMENT AMID	(LBS.)	1.2993E+06	9.0072E+06	3.8365E+06
EPS2-WAVE & B.M.	(RAD.)	1.019	0.069	6.283

SHIP/EFF. WAVE LENGTH	(NON-D.)	2.892	3.270	3.659
EFFECTIVE WAVE LENGTH	(FEET)	345.105	305.185	272.735
ENCOUNTER FREQUENCY	(1/SEC.)	1.160	1.260	1.360
RESONANT FREQUENCY	(1/SEC.)	1.960	1.960	1.960
SPEED	(FT/SEC)	21.560	21.560	21.560
WAVE HEADING	(DEG.)	174.000	174.000	174.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9074E+06	1.9074E+06	1.9074E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.8596E+03	-2.8596E+03	-2.8596E+03
TOTAL ADDED MASS	(SLUGS)	2.9162E+06	2.9162E+06	2.9162E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	9.0365E+04	9.0365E+04	9.0365E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.8269E+04	4.8269E+04	4.8269E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.0930E+04	1.0930E+04	1.0930E+04
TOTAL DAMPING	(SLUGS/SEC)	1.4956E+05	1.4956E+05	1.4956E+05
DAMPING/ADDED MASS	(1/SEC.)	0.051	0.051	0.051
PHI-FORCE & MOTION	(RAD.)	0.024	0.029	0.035
MAGNIFICATION FACTOR	(NON-D.)	1.5387E+00	1.7036E+00	1.9273E+00
F COS(EPS)	(LBS.)	-1.8978E+05	-1.9355E+05	6.0463E+04
F SIN(EPS)	(LBS.)	-8.8299E+04	-7.4736E+04	8.3237E+03
F-WAVE EXCITING FORCE	(LBS.)	2.0932E+05	2.0748E+05	6.1033E+04
EPS-FORCE & WAVE	(RAD.)	3.577	3.510	0.137
DEFLECTION AT STERN	(FEET)	2.8748E-02	3.1552E-02	1.0500E-02
EPS1-WAVE & VIBRATION	(RAD.)	-3.553	-3.481	-0.102
M COS(EPS2)	(LBS.)	-1.0515E+07	-1.5940E+07	5.9717E+06
M SIN(EPS2)	(LBS.)	1.5158E+06	4.4927E+06	3.0298E+05
M-BENDING MOMENT AMID	(LBS.)	1.0624E+07	1.6561E+07	5.9793E+06
EPS2-WAVE & B.M.	(RAD.)	2.998	2.867	0.051

SHIP/EFF. WAVE LENGTH	(NON-D.)	4.058	4.466	4.883
EFFECTIVE WAVE LENGTH	(FEET)	245.922	223.454	204.396
ENCOUNTER FREQUENCY	(1/SEC.)	1.460	1.560	1.660
RESONANT FREQUENCY	(1/SEC.)	1.960	1.960	1.960
SPEED	(FT/SEC)	21.560	21.560	21.560
WAVE HEADING	(DEG.)	174.000	174.000	174.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9074E+06	1.9074E+06	1.9074E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.8596E+03	-2.8596E+03	-2.8596E+03
TOTAL ADDED MASS	(SLUGS)	2.9162E+06	2.9162E+06	2.9162E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	9.0365E+04	9.0365E+04	9.0365E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.8269E+04	4.8269E+04	4.8269E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.0930E+04	1.0930E+04	1.0930E+04
TOTAL DAMPING	(SLUGS/SEC)	1.4956E+05	1.4956E+05	1.4956E+05
DAMPING/ADDED MASS	(1/SEC.)	0.051	0.051	0.051
PHI-FORCE & MOTION	(RAD.)	0.044	0.057	0.078
MAGNIFICATION FACTOR	(NON-D.)	2.2444E+00	2.7240E+00	3.5266E+00
F COS(EPS)	(LBS.)	2.0971E+05	6.6023E+04	-1.4229E+05
F SIN(EPS)	(LBS.)	7.7502E+04	6.1259E+04	-2.1925E+04
F-WAVE EXCITING FORCE	(LBS.)	2.2357E+05	9.0065E+04	1.4396E+05
EPS-FORCE & WAVE	(RAD.)	0.354	0.748	3.294
DEFLECTION AT STERN	(FEET)	4.4790E-02	2.1899E-02	4.5319E-02
EPS1-WAVE & VIBRATION	(RAD.)	-0.310	-0.691	-3.216
M COS(EPS2)	(LBS.)	3.2764E+07	1.5500E+07	-4.5658E+07
M SIN(EPS2)	(LBS.)	-7.2725E+06	-1.1991E+07	2.1123E+05
M-BENDING MOMENT AMID	(LBS.)	3.3561E+07	1.9597E+07	4.5659E+07
EPS2-WAVE & B.M.	(RAD.)	6.065	5.625	3.137

SHIP/EFF. WAVE LENGTH	(NON-D.)	5.307	5.738	6.177
EFFECTIVE WAVE LENGTH	(FEET)	188.057	173.918	161.579
ENCOUNTER FREQUENCY	(1/SEC.)	1.760	1.860	1.960
RESONANT FREQUENCY	(1/SEC.)	1.960	1.960	1.960
SPEED	(FT/SEC)	21.560	21.560	21.560
WAVE HEADING	(DEG.)	174.000	174.000	174.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9074E+06	1.9074E+06	1.9074E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.8596E+03	-2.8596E+03	-2.8596E+03
TOTAL ADDED MASS	(SLUGS)	2.9162E+06	2.9162E+06	2.9162E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	9.0365E+04	9.0365E+04	9.0365E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.8269E+04	4.8269E+04	4.8269E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.0930E+04	1.0930E+04	1.0930E+04
TOTAL DAMPING	(SLUGS/SEC)	1.4956E+05	1.4956E+05	1.4956E+05
DAMPING/ADDED MASS	(1/SEC.)	0.051	0.051	0.051
PHI-FORCE & MOTION	(RAD.)	0.121	0.245	1.571
MAGNIFICATION FACTOR	(NON-D.)	5.1259E+00	9.7569E+00	3.8216E+01
F COS(EPS)	(LBS.)	-1.2403E+05	5.6164E+04	1.1545E+05
F SIN(EPS)	(LBS.)	-7.6355E+04	-3.5416E+04	5.0742E+04
F-WAVE EXCITING FORCE	(LBS.)	1.4565E+05	6.6398E+04	1.2611E+05
EPS-FORCE & WAVE	(RAD.)	3.693	5.721	0.414
DEFLECTION AT STERN	(FEET)	6.6639E-02	5.7828E-02	4.3019E-01
EPS1-WAVE & VIBRATION	(RAD.)	-3.573	-5.476	1.157
M COS(EPS2)	(LBS.)	-7.2694E+07	5.0926E+07	2.5149E+08
M SIN(EPS2)	(LBS.)	3.0195E+07	5.7971E+07	5.9842E+08
M-BENDING MOMENT AMID	(LBS.)	7.8715E+07	7.7162E+07	6.4912E+08
EPS2-WAVE & B.M.	(RAD.)	2.748	0.850	1.173

SHIP/EFF. WAVE LENGTH	(NON-D.)	6.621	7.072	7.528
EFFECTIVE WAVE LENGTH	(FEET)	150.731	141.129	132.578
ENCOUNTER FREQUENCY	(1/SEC.)	2.060	2.160	2.260
RESONANT FREQUENCY	(1/SEC.)	1.960	1.960	1.960
SPEED	(FT/SEC)	21.560	21.560	21.560
WAVE HEADING	(DEG.)	174.000	174.000	174.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9074E+06	1.9074E+06	1.9074E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.8596E+03	-2.8596E+03	-2.8596E+03
TOTAL ADDED MASS	(SLUGS)	2.9162E+06	2.9162E+06	2.9162E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	9.0365E+04	9.0365E+04	9.0365E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.8269E+04	4.8269E+04	4.8269E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.0930E+04	1.0930E+04	1.0930E+04
TOTAL DAMPING	(SLUGS/SEC)	1.4956E+05	1.4956E+05	1.4956E+05
DAMPING/ADDED MASS	(1/SEC.)	0.051	0.051	0.051
PHI-FORCE & MOTION	(RAD.)	2.885	3.008	3.050
MAGNIFICATION FACTOR	(NON-D.)	9.2424E+00	4.6206E+00	3.0218E+00
F COS(EPS)	(LBS.)	-8.1520E+02	-7.8658E+04	-1.6335E+04
F SIN(EPS)	(LBS.)	6.7289E+04	-1.2003E+04	-7.3963E+04
F-WAVE EXCITING FORCE	(LBS.)	6.7294E+04	7.9568E+04	7.5745E+04
EPS-FORCE & WAVE	(RAD.)	1.583	3.293	4.495
DEFLECTION AT STERN	(FEET)	5.5517E-02	3.2817E-02	2.0431E-02
EPS1-WAVE & VIBRATION	(RAD.)	1.302	-0.285	-1.445
M COS(EPS2)	(LBS.)	2.3273E+07	5.9260E+07	6.1335E+06
M SIN(EPS2)	(LBS.)	8.9797E+07	-1.6231E+07	-4.1976E+07
M-BENDING MOMENT AMID	(LBS.)	9.2764E+07	6.1443E+07	4.2422E+07
EPS2-WAVE & B.M.	(RAD.)	1.317	6.016	4.857

SHIP/EFF. WAVE LENGTH(NON-D.)	7.989	8.455	8.926
EFFECTIVE WAVE LENGTH(FEET)	124.922	118.033	111.804
ENCOUNTER FREQUENCY (1/SEC.)	2.360	2.460	2.560
RESONANT FREQUENCY (1/SEC.)	1.960	1.960	1.960
SPEED (FT/SEC)	21.560	21.560	21.560
WAVE HEADING (DEG.)	174.000	174.000	174.000
HYDRODYNAMIC A.M. (SLUGS)	1.9074E+06	1.9074E+06	1.9074E+06
SHIP MASS (SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M. (SLUGS)	-2.8596E+03	-2.8596E+03	-2.8596E+03
TOTAL ADDED MASS (SLUGS)	2.9162E+06	2.9162E+06	2.9162E+06
HYDRODYNAMIC DAMPING (SLUGS/SEC)	9.0365E+04	9.0365E+04	9.0365E+04
SPEED DEPENDENT DAMP.(SLUGS/SEC)	4.8269E+04	4.8269E+04	4.8269E+04
STRUCTURAL DAMPING (SLUGS/SEC)	1.0930E+04	1.0930E+04	1.0930E+04
TOTAL DAMPING (SLUGS/SEC)	1.4956E+05	1.4956E+05	1.4956E+05
DAMPING/ADDED MASS (1/SEC.)	0.051	0.051	0.051
PHI-FORCE & MOTION (RAD.)	3.072	3.085	3.093
MAGNIFICATION FACTOR (NON-D.)	2.2177E+00	1.7355E+00	1.4149E+00
F COS(EPS) (LBS.)	4.3582E+04	8.4134E+03	-2.1591E+04
F SIN(EPS) (LBS.)	-2.2310E+04	6.5861E+04	4.6889E+04
F-WAVE EXCITING FORCE(LBS.)	4.8961E+04	6.6396E+04	5.1621E+04
EPS-FORCE & WAVE (RAD.)	5.810	1.444	2.002
DEFLECTION AT STERN (FEET)	9.6921E-03	1.0285E-02	6.5194E-03
EPS1-WAVE & VIBRATION(RAD.)	-2.738	1.641	1.091
M COS(EPS2) (LBS.)	-2.0258E+07	-2.3295E+06	8.0244E+06
M SIN(EPS2) (LBS.)	-9.0939E+06	2.5785E+07	1.6043E+07
M-BENDING MOMENT AMID(LBS.)	2.2205E+07	2.5890E+07	1.7938E+07
EPS2-WAVE & B.M. (RAD.)	3.564	1.661	1.107

SHIP/EFF. WAVE LENGTH(NON-D.)	9.402	9.882	10.366
EFFECTIVE WAVE LENGTH(FEET)	106.149	100.995	96.280
ENCOUNTER FREQUENCY (1/SEC.)	2.660	2.760	2.860
RESONANT FREQUENCY (1/SEC.)	1.960	1.960	1.960
SPEED (FT/SEC)	21.560	21.560	21.560
WAVE HEADING (DEG.)	174.000	174.000	174.000
HYDRODYNAMIC A.M. (SLUGS)	1.9074E+06	1.9074E+06	1.9074E+06
SHIP MASS (SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M. (SLUGS)	-2.8596E+03	-2.8596E+03	-2.8596E+03
TOTAL ADDED MASS (SLUGS)	2.9162E+06	2.9162E+06	2.9162E+06
HYDRODYNAMIC DAMPING (SLUGS/SEC)	9.0365E+04	9.0365E+04	9.0365E+04
SPEED DEPENDENT DAMP.(SLUGS/SEC)	4.8269E+04	4.8269E+04	4.8269E+04
STRUCTURAL DAMPING (SLUGS/SEC)	1.0930E+04	1.0930E+04	1.0930E+04
TOTAL DAMPING (SLUGS/SEC)	1.4956E+05	1.4956E+05	1.4956E+05
DAMPING/ADDED MASS (1/SEC.)	0.051	0.051	0.051
PHI-FORCE & MOTION (RAD.)	3.099	3.104	3.108
MAGNIFICATION FACTOR (NON-D.)	1.1868E+00	1.0167E+00	8.8506E-01
F COS(EPS) (LBS.)	1.0458E+04	1.2645E+04	-3.1456E+04
F SIN(EPS) (LBS.)	-5.2142E+04	-6.2686E+04	3.8043E+04
F-WAVE EXCITING FORCE(LBS.)	5.3180E+04	6.3949E+04	4.9363E+04
EPS-FORCE & WAVE (RAD.)	4.910	4.911	2.262
DEFLECTION AT STERN (FEET)	5.6339E-03	5.8033E-03	3.8998E-03
EPS1-WAVE & VIBRATION(RAD.)	-1.811	-1.807	0.846
M COS(EPS2) (LBS.)	-3.6190E+06	-4.1348E+06	8.7565E+06
M SIN(EPS2) (LBS.)	-1.6422E+07	-1.8387E+07	1.0351E+07
M-BENDING MOMENT AMID(LBS.)	1.6816E+07	1.8846E+07	1.3558E+07
EPS2-WAVE & B.M. (RAD.)	4.495	4.491	0.869

SHIP/EFF. WAVE LENGTH	(NON-D.)	10.853
EFFECTIVE WAVE LENGTH	(FEET)	91.953
ENCOUNTER FREQUENCY	(1/SEC.)	2.960
RESONANT FREQUENCY	(1/SEC.)	1.960
SPEED	(FT/SEC)	21.560
WAVE HEADING	(DEG.)	174.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9074E+06
SHIP MASS	(SLUGS)	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.8596E+03
TOTAL ADDED MASS	(SLUGS)	2.9162E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	9.0365E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.8269E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.0930E+04
TOTAL DAMPING	(SLUGS/SEC)	1.4956E+05
DAMPING/ADDED MASS	(1/SEC.)	0.051
PHI-FORCE & MOTION	(RAD.)	3.111
MAGNIFICATION FACTOR	(NON-D.)	7.8044E-01
F COS(EPS)	(LBS.)	-1.2663E+04
F SIN(EPS)	(LBS.)	7.2219E+04
F-WAVE EXCITING FORCE	(LBS.)	7.3321E+04
EPS-FORCE & WAVE	(RAD.)	1.744
DEFLECTION AT STERN	(FEET)	5.1078E-03
EPS1-WAVE & VIBRATION	(RAD.)	1.366
M COS(EPS2)	(LBS.)	3.6373E+06
M SIN(EPS2)	(LBS.)	1.8965E+07
M-BENDING MOMENT AMID	(LBS.)	1.9311E+07
EPS2-WAVE & B.M.	(RAD.)	1.381

SHIP/EFF. WAVE LENGTH	(NON-D.)	0.989	1.279	1.591
EFFECTIVE WAVE LENGTH	(FEET)	1009.283	780.087	627.106
ENCOUNTER FREQUENCY	(1/SEC.)	0.580	0.680	0.780
RESONANT FREQUENCY	(1/SEC.)	2.080	2.080	2.080
SPEED	(FT/SEC)	20.830	20.830	20.830
WAVE HEADING	(DEG.)	171.000	171.000	171.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.4141E+03	-2.4141E+03	-2.4141E+03
TOTAL ADDED MASS	(SLUGS)	2.9325E+06	2.9325E+06	2.9325E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.5735E+04	4.5735E+04	4.5735E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3738E+05	1.3738E+05	1.3738E+05
DAMPING/ADDED MASS	(1/SEC.)	0.047	0.047	0.047
PHI-FORCE & MOTION	(RAD.)	0.007	0.008	0.010
MAGNIFICATION FACTOR	(NON-D.)	1.0843E+00	1.1196E+00	1.1636E+00
F COS(EPS)	(LBS.)	-1.2686E+06	-9.9662E+05	-3.6313E+05
F SIN(EPS)	(LBS.)	-7.7058E+04	4.4559E+03	8.1620E+04
F-WAVE EXCITING FORCE	(LBS.)	1.2710E+06	9.9663E+05	3.7219E+05
EPS-FORCE & WAVE	(RAD.)	3.202	3.137	2.920
DEFLECTION AT STERN	(FEET)	1.0862E-01	8.7951E-02	3.4134E-02
EPS1-WAVE & VIBRATION	(RAD.)	-3.195	-3.129	-2.911
M COS(EPS2)	(LBS.)	-1.0273E+07	-1.6644E+07	-4.3770E+06
M SIN(EPS2)	(LBS.)	-3.4514E+07	-6.0255E+06	2.9539E+06
M-BENDING MOMENT AMID	(LBS.)	3.6010E+07	1.7701E+07	5.2805E+06
EPS2-WAVE & B.M.	(RAD.)	4.423	3.489	2.548

SHIP/EFF. WAVE LENGTH	(NON-D.)	1.922	2.270	2.633
EFFECTIVE WAVE LENGTH	(FEET)	519.146	439.646	379.107
ENCOUNTER FREQUENCY	(1/SEC.)	0.880	0.980	1.080
RESONANT FREQUENCY	(1/SEC.)	2.080	2.080	2.080
SPEED	(FT/SEC)	20.830	20.830	20.830
WAVE HEADING	(DEG.)	171.000	171.000	171.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.4141E+03	-2.4141E+03	-2.4141E+03
TOTAL ADDED MASS	(SLUGS)	2.9325E+06	2.9325E+06	2.9325E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.5735E+04	4.5735E+04	4.5735E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3738E+05	1.3738E+05	1.3738E+05
DAMPING/ADDED MASS	(1/SEC.)	0.047	0.047	0.047
PHI-FORCE & MOTION	(RAD.)	0.012	0.014	0.016
MAGNIFICATION FACTOR	(NON-D.)	1.2179E+00	1.2852E+00	1.3689E+00
F COS(EPS)	(LBS.)	1.8690E+05	2.8104E+05	-4.7562E+03
F SIN(EPS)	(LBS.)	9.9047E+04	4.1151E+04	-4.4534E+04
F-WAVE EXCITING FORCE	(LBS.)	2.1152E+05	2.8404E+05	4.4788E+04
EPS-FORCE & WAVE	(RAD.)	0.487	0.145	4.606
DEFLECTION AT STERN	(FEET)	2.0305E-02	2.8773E-02	4.8325E-03
EPS1-WAVE & VIBRATION	(RAD.)	-0.476	-0.132	-4.590
M COS(EPS2)	(LBS.)	2.4230E+06	7.4637E+06	-1.9161E+05
M SIN(EPS2)	(LBS.)	1.6183E+06	-2.0753E+05	8.9704E+05
M-BENDING MOMENT AMID	(LBS.)	2.9137E+06	7.4666E+06	9.1727E+05
EPS2-WAVE & B.M.	(RAD.)	0.589	6.255	1.781

SHIP/EFF. WAVE LENGTH	(NON-D.)	3.008	3.396	3.795
EFFECTIVE WAVE LENGTH	(FEET)	331.740	293.842	262.948
ENCOUNTER FREQUENCY	(1/SEC.)	1.180	1.280	1.380
RESONANT FREQUENCY	(1/SEC.)	2.080	2.080	2.080
SPEED	(FT/SEC)	20.830	20.830	20.830
WAVE HEADING	(DEG.)	171.000	171.000	171.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.4141E+03	-2.4141E+03	-2.4141E+03
TOTAL ADDED MASS	(SLUGS)	2.9325E+06	2.9325E+06	2.9325E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.5735E+04	4.5735E+04	4.5735E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3738E+05	1.3738E+05	1.3738E+05
DAMPING/ADDED MASS	(1/SEC.)	0.047	0.047	0.047
PHI-FORCE & MOTION	(RAD.)	0.019	0.022	0.027
MAGNIFICATION FACTOR	(NON-D.)	1.4743E+00	1.6091E+00	1.7857E+00
F COS(EPS)	(LBS.)	-2.3187E+05	-1.1410E+05	1.5116E+05
F SIN(EPS)	(LBS.)	-8.3434E+04	-4.2937E+04	3.4208E+04
F-WAVE EXCITING FORCE	(LBS.)	2.4643E+05	1.2191E+05	1.5498E+05
EPS-FORCE & WAVE	(RAD.)	3.487	3.502	0.223
DEFLECTION AT STERN	(FEET)	2.8636E-02	1.5462E-02	2.1813E-02
EPS1-WAVE & VIBRATION	(RAD.)	-3.468	-3.479	-0.196
M COS(EPS2)	(LBS.)	-1.2074E+07	-8.0040E+06	1.3675E+07
M SIN(EPS2)	(LBS.)	1.5873E+06	2.6977E+06	-7.2261E+05
M-BENDING MOMENT AMID	(LBS.)	1.2178E+07	8.4464E+06	1.3694E+07
EPS2-WAVE & B.M.	(RAD.)	3.011	2.817	6.230

SHIP/EFF. WAVE LENGTH	(NON-D.)	4.205	4.623	5.050
EFFECTIVE WAVE LENGTH	(FEET)	237.358	215.872	197.615
ENCOUNTER FREQUENCY	(1/SEC.)	1.480	1.580	1.680
RESONANT FREQUENCY	(1/SEC.)	2.080	2.080	2.080
SPEED	(FT/SEC)	20.830	20.830	20.830
WAVE HEADING	(DEG.)	171.000	171.000	171.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.4141E+03	-2.4141E+03	-2.4141E+03
TOTAL ADDED MASS	(SLUGS)	2.9325E+06	2.9325E+06	2.9325E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.5735E+04	4.5735E+04	4.5735E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3738E+05	1.3738E+05	1.3738E+05
DAMPING/ADDED MASS	(1/SEC.)	0.047	0.047	0.047
PHI-FORCE & MOTION	(RAD.)	0.032	0.040	0.052
MAGNIFICATION FACTOR	(NON-D.)	2.0244E+00	2.3622E+00	2.8727E+00
F COS(EPS)	(LBS.)	1.8458E+05	-3.7425E+04	-1.7343E+05
F SIN(EPS)	(LBS.)	7.0083E+04	2.9290E+04	-4.2014E+04
F-WAVE EXCITING FORCE	(LBS.)	1.9743E+05	4.7524E+04	1.7844E+05
EPS-FORCE & WAVE	(RAD.)	0.363	2.478	3.379
DEFLECTION AT STERN	(FEET)	3.1503E-02	8.8484E-03	4.0404E-02
EPS1-WAVE & VIBRATION	(RAD.)	-0.330	-2.437	-3.327
M COS(EPS2)	(LBS.)	2.4139E+07	-5.6488E+06	-4.2645E+07
M SIN(EPS2)	(LBS.)	-6.6866E+06	-5.6945E+06	5.4781E+06
M-BENDING MOMENT AMID	(LBS.)	2.5048E+07	8.0210E+06	4.2996E+07
EPS2-WAVE & B.M.	(RAD.)	6.013	3.931	3.014

SHIP/EFF. WAVE LENGTH	(NON-D.)	5.485	5.928	6.377
EFFECTIVE WAVE LENGTH	(FEET)	181.939	168.355	156.488
ENCOUNTER FREQUENCY	(1/SEC.)	1.780	1.880	1.980
RESONANT FREQUENCY	(1/SEC.)	2.080	2.080	2.080
SPEED	(FT/SEC)	20.830	20.830	20.830
WAVE HEADING	(DEG.)	171.000	171.000	171.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.4141E+03	-2.4141E+03	-2.4141E+03
TOTAL ADDED MASS	(SLUGS)	2.9325E+06	2.9325E+06	2.9325E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.5735E+04	4.5735E+04	4.5735E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3738E+05	1.3738E+05	1.3738E+05
DAMPING/ADDED MASS	(1/SEC.)	0.047	0.047	0.047
PHI-FORCE & MOTION	(RAD.)	0.072	0.111	0.225
MAGNIFICATION FACTOR	(NON-D.)	3.7264E+00	5.4292E+00	1.0388E+01
F COS(EPS)	(LBS.)	-4.3566E+04	1.1947E+05	7.1126E+04
F SIN(EPS)	(LBS.)	-6.0901E+04	-2.3631E+03	5.9490E+04
F-WAVE EXCITING FORCE	(LBS.)	7.4880E+04	1.1950E+05	9.2725E+04
EPS-FORCE & WAVE	(RAD.)	4.091	6.263	0.697
DEFLECTION AT STERN	(FEET)	2.1993E-02	5.1135E-02	7.5925E-02
EPS1-WAVE & VIBRATION	(RAD.)	-4.020	-6.153	-0.472
M COS(EPS2)	(LBS.)	-1.7879E+07	6.9701E+07	1.0726E+08
M SIN(EPS2)	(LBS.)	2.0154E+07	1.2256E+07	-5.0761E+07
M-BENDING MOMENT AMID	(LBS.)	2.6942E+07	7.0770E+07	1.1866E+08
EPS2-WAVE & B.M.	(RAD.)	2.296	0.174	5.841

SHIP/EFF. WAVE LENGTH	(NON-D.)	6.834	7.296	7.764
EFFECTIVE WAVE LENGTH	(FEET)	146.043	136.791	128.545
ENCOUNTER FREQUENCY	(1/SEC.)	2.080	2.180	2.280
RESONANT FREQUENCY	(1/SEC.)	2.080	2.080	2.080
SPEED	(FT/SEC)	20.830	20.830	20.830
WAVE HEADING	(DEG.)	171.000	171.000	171.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.4141E+03	-2.4141E+03	-2.4141E+03
TOTAL ADDED MASS	(SLUGS)	2.9325E+06	2.9325E+06	2.9325E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.5735E+04	4.5735E+04	4.5735E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3738E+05	1.3738E+05	1.3738E+05
DAMPING/ADDED MASS	(1/SEC.)	0.047	0.047	0.047
PHI-FORCE & MOTION	(RAD.)	1.571	2.906	3.020
MAGNIFICATION FACTOR	(NON-D.)	4.4401E+01	9.8761E+00	4.9247E+00
F COS(EPS)	(LBS.)	-6.7784E+04	-6.2662E+04	3.6554E+04
F SIN(EPS)	(LBS.)	3.7439E+04	-4.1284E+04	-5.7226E+04
F-WAVE EXCITING FORCE	(LBS.)	7.7436E+04	7.5039E+04	6.7904E+04
EPS-FORCE & WAVE	(RAD.)	2.637	3.724	5.281
DEFLECTION AT STERN	(FEET)	2.7100E-01	5.8412E-02	2.6358E-02
EPS1-WAVE & VIBRATION	(RAD.)	-1.066	-0.818	-2.261
M COS(EPS2)	(LBS.)	2.3770E+08	7.8864E+07	-3.4743E+07
M SIN(EPS2)	(LBS.)	-4.0748E+08	-8.0157E+07	-4.4233E+07
M-BENDING MOMENT AMID	(LBS.)	4.7175E+08	1.1245E+08	5.6247E+07
EPS2-WAVE & B.M.	(RAD.)	5.240	5.490	4.047

SHIP/EFF. WAVE LENGTH	(NON-D.)	8.237	8.716	9.200
EFFECTIVE WAVE LENGTH	(FEET)	121.156	114.503	108.484
ENCOUNTER FREQUENCY	(1/SEC.)	2.380	2.480	2.580
RESONANT FREQUENCY	(1/SEC.)	2.080	2.080	2.080
SPEED	(FT/SEC)	20.830	20.830	20.830
WAVE HEADING	(DEG.)	171.000	171.000	171.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.4141E+03	-2.4141E+03	-2.4141E+03
TOTAL ADDED MASS	(SLUGS)	2.9325E+06	2.9325E+06	2.9325E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.5735E+04	4.5735E+04	4.5735E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3738E+05	1.3738E+05	1.3738E+05
DAMPING/ADDED MASS	(1/SEC.)	0.047	0.047	0.047
PHI-FORCE & MOTION	(RAD.)	3.058	3.078	3.090
MAGNIFICATION FACTOR	(NON-D.)	3.2223E+00	2.3671E+00	1.8543E+00
F COS(EPS)	(LBS.)	3.9919E+04	-2.4797E+04	-1.5496E+04
F SIN(EPS)	(LBS.)	2.0114E+04	6.5820E+04	-2.3438E+03
F-WAVE EXCITING FORCE	(LBS.)	4.4700E+04	7.0336E+04	1.5672E+04
EPS-FORCE & WAVE	(RAD.)	0.467	1.931	3.292
DEFLECTION AT STERN	(FEET)	1.1353E-02	1.3123E-02	2.2905E-03
EPS1-WAVE & VIBRATION	(RAD.)	2.592	1.147	-0.202
M COS(EPS2)	(LBS.)	-2.3105E+07	1.3218E+07	6.3618E+06
M SIN(EPS2)	(LBS.)	1.3416E+07	3.1220E+07	-1.1511E+06
M-BENDING MOMENT AMID	(LBS.)	2.6717E+07	3.3903E+07	6.4651E+06
EPS2-WAVE & B.M.	(RAD.)	2.616	1.170	6.104

SHIP/EFF. WAVE LENGTH	(NON-D.)	9.688	10.180	10.677
EFFECTIVE WAVE LENGTH	(FEET)	103.017	98.032	93.470
ENCOUNTER FREQUENCY	(1/SEC.)	2.680	2.780	2.880
RESONANT FREQUENCY	(1/SEC.)	2.080	2.080	2.080
SPEED	(FT/SEC)	20.830	20.830	20.830
WAVE HEADING	(DEG.)	171.000	171.000	171.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.4141E+03	-2.4141E+03	-2.4141E+03
TOTAL ADDED MASS	(SLUGS)	2.9325E+06	2.9325E+06	2.9325E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.5735E+04	4.5735E+04	4.5735E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3738E+05	1.3738E+05	1.3738E+05
DAMPING/ADDED MASS	(1/SEC.)	0.047	0.047	0.047
PHI-FORCE & MOTION	(RAD.)	3.098	3.103	3.108
MAGNIFICATION FACTOR	(NON-D.)	1.5134E+00	1.2708E+00	1.0897E+00
F COS(EPS)	(LBS.)	2.5674E+04	-6.0610E+03	-3.2808E+04
F SIN(EPS)	(LBS.)	-6.8717E+04	-1.0559E+04	6.9624E+04
F-WAVE EXCITING FORCE	(LBS.)	7.3356E+04	1.2175E+04	7.6967E+04
EPS-FORCE & WAVE	(RAD.)	5.070	4.191	2.011
DEFLECTION AT STERN	(FEET)	5.7502E-03	1.2195E-03	6.6106E-03
EPS1-WAVE & VIBRATION	(RAD.)	-1.972	-1.088	1.096
M COS(EPS2)	(LBS.)	-9.8945E+06	1.9197E+06	1.0326E+07
M SIN(EPS2)	(LBS.)	-2.4939E+07	-3.5443E+06	2.1325E+07
M-BENDING MOMENT AMID	(LBS.)	2.6830E+07	4.0308E+06	2.3694E+07
EPS2-WAVE & B.M.	(RAD.)	4.335	5.209	1.120

SHIP/EFF. WAVE LENGTH	(NON-D.)	11.178
EFFECTIVE WAVE LENGTH	(FEET)	89.282
ENCOUNTER FREQUENCY	(1/SEC.)	2.980
RESONANT FREQUENCY	(1/SEC.)	2.080
SPEED	(FT/SEC)	20.830
WAVE HEADING	(DEG.)	171.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.4141E+03
TOTAL ADDED MASS	(SLUGS)	2.9325E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.5735E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3738E+05
DAMPING/ADDED MASS	(1/SEC.)	0.047
PHI-FORCE & MOTION	(RAD.)	3.111
MAGNIFICATION FACTOR	(NON-D.)	9.4958E-01
F COS(EPS)	(LBS.)	2.4366E+04
F SIN(EPS)	(LBS.)	1.8944E+04
F-WAVE EXCITING FORCE	(LBS.)	3.0864E+04
EPS-FORCE & WAVE	(RAD.)	0.661
DEFLECTION AT STERN	(FEET)	2.3100E-03
EPS1-WAVE & VIBRATION	(RAD.)	2.450
M COS(EPS2)	(LBS.)	-6.8778E+06
M SIN(EPS2)	(LBS.)	5.5627E+06
M-BENDING MOMENT AMID	(LBS.)	8.8458E+06
EPS2-WAVE & B.M.	(RAD.)	2.462

SHIP/EFF. WAVE LENGTH	(NON-D.)	0.943	1.228	1.536
EFFECTIVE WAVE LENGTH	(FEET)	1058.582	812.527	649.540
ENCOUNTER FREQUENCY	(1/SEC.)	0.573	0.673	0.773
RESONANT FREQUENCY	(1/SEC.)	2.073	2.073	2.073
SPEED	(FT/SEC)	19.800	19.800	19.800
WAVE HEADING	(DEG.)	157.000	157.000	157.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9245E+06	1.9245E+06	1.9245E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.3127E+03	-2.3127E+03	-2.3127E+03
TOTAL ADDED MASS	(SLUGS)	2.9339E+06	2.9339E+06	2.9339E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	8.0071E+04	8.0071E+04	8.0071E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3903E+04	4.3903E+04	4.3903E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2103E+04	1.2103E+04	1.2103E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3608E+05	1.3608E+05	1.3608E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION	(RAD.)	0.007	0.008	0.010
MAGNIFICATION FACTOR	(NON-D.)	1.0827E+00	1.1178E+00	1.1614E+00
F COS(EPS)	(LBS.)	-1.2156E+06	-1.0190E+06	-4.3467E+05
F SIN(EPS)	(LBS.)	-8.7421E+04	-1.2320E+04	6.8707E+04
F-WAVE EXCITING FORCE	(LBS.)	1.2188E+06	1.0191E+06	4.4007E+05
EPS-FORCE & WAVE	(RAD.)	3.213	3.154	2.985
DEFLECTION AT STERN	(FEET)	1.0466E-01	9.0350E-02	4.0540E-02
EPS1-WAVE & VIBRATION	(RAD.)	-3.207	-3.146	-2.975
M COS(EPS2)	(LBS.)	-6.3669E+06	-1.6317E+07	-5.7157E+06
M SIN(EPS2)	(LBS.)	-3.5849E+07	-8.9411E+06	2.9382E+06
M-BENDING MOMENT AMID	(LBS.)	3.6410E+07	1.8606E+07	6.4267E+06
EPS2-WAVE & B.M.	(RAD.)	4.537	3.643	2.667

SHIP/EFF. WAVE LENGTH	(NON-D.)	1.865	2.211	2.572
EFFECTIVE WAVE LENGTH	(FEET)	535.226	451.479	387.986
ENCOUNTER FREQUENCY	(1/SEC.)	0.873	0.973	1.073
RESONANT FREQUENCY	(1/SEC.)	2.073	2.073	2.073
SPEED	(FT/SEC)	19.800	19.800	19.800
WAVE HEADING	(DEG.)	157.000	157.000	157.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9245E+06	1.9245E+06	1.9245E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.3127E+03	-2.3127E+03	-2.3127E+03
TOTAL ADDED MASS	(SLUGS)	2.9339E+06	2.9339E+06	2.9339E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	8.0071E+04	8.0071E+04	8.0071E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3903E+04	4.3903E+04	4.3903E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2103E+04	1.2103E+04	1.2103E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3608E+05	1.3608E+05	1.3608E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION	(RAD.)	0.011	0.013	0.016
MAGNIFICATION FACTOR	(NON-D.)	1.2155E+00	1.2824E+00	1.3658E+00
F COS(EPS)	(LBS.)	1.2990E+05	2.7818E+05	2.4920E+04
F SIN(EPS)	(LBS.)	9.9847E+04	5.5662E+04	-2.8136E+04
F-WAVE EXCITING FORCE	(LBS.)	1.6384E+05	2.8369E+05	3.7585E+04
EPS-FORCE & WAVE	(RAD.)	0.655	0.197	5.437
DEFLECTION AT STERN	(FEET)	1.5796E-02	2.8857E-02	4.0715E-03
EPS1-WAVE & VIBRATION	(RAD.)	-0.644	-0.184	-5.421
M COS(EPS2)	(LBS.)	1.4434E+06	7.2198E+06	7.3900E+05
M SIN(EPS2)	(LBS.)	1.1081E+06	-1.4503E+05	5.7288E+05
M BENDING MOMENT AMID	(LBS.)	1.8197E+06	7.2212E+06	9.3504E+05
EPS2-WAVE & B.M.	(RAD.)	0.655	6.263	0.659

SHIP/EFF. WAVE LENGTH	(NON-D.)	2.948	3.337	3.738
EFFECTIVE WAVE LENGTH	(FEET)	338.498	299.036	266.963
ENCOUNTER FREQUENCY	(1/SEC.)	1.173	1.273	1.373
RESONANT FREQUENCY	(1/SEC.)	2.073	2.073	2.073
SPEED	(FT/SEC)	19.800	19.800	19.800
WAVE HEADING	(DEG.)	157.000	157.000	157.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9245E+06	1.9245E+06	1.9245E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.3127E+03	-2.3127E+03	-2.3127E+03
TOTAL ADDED MASS	(SLUGS)	2.9339E+06	2.9339E+06	2.9339E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	8.0071E+04	8.0071E+04	8.0071E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3903E+04	4.3903E+04	4.3903E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2103E+04	1.2103E+04	1.2103E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3608E+05	1.3608E+05	1.3608E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION	(RAD.)	0.019	0.022	0.026
MAGNIFICATION FACTOR	(NON-D.)	1.4707E+00	1.6050E+00	1.7809E+00
F COS(EPS)	(LBS.)	-2.1843E+05	-1.3130E+05	1.3178E+05
F SIN(EPS)	(LBS.)	-7.9346E+04	-5.4447E+04	1.8876E+04
F-WAVE EXCITING FORCE	(LBS.)	2.3240E+05	1.4214E+05	1.3312E+05
EPS-FORCE & WAVE	(RAD.)	3.490	3.535	0.142
DEFLECTION AT STERN	(FEET)	2.7110E-02	1.8095E-02	1.8804E-02
EPS1-WAVE & VIBRATION	(RAD.)	-3.471	-3.513	-0.116
M COS(EPS2)	(LBS.)	-1.0968E+07	-9.1403E+06	1.1586E+07
M SIN(EPS2)	(LBS.)	1.4167E+06	3.3154E+06	2.0081E+05
M-BENDING MOMENT AMID	(LBS.)	1.1060E+07	9.7230E+06	1.1588E+07
EPS2-WAVE & B.M.	(RAD.)	3.013	2.794	0.017

SHIP/EFF. WAVE LENGTH	(NON-D.)	4.150	4.572	5.003
EFFECTIVE WAVE LENGTH	(FEET)	240.470	218.278	199.464
ENCOUNTER FREQUENCY	(1/SEC.)	1.473	1.573	1.673
RESONANT FREQUENCY	(1/SEC.)	2.073	2.073	2.073
SPEED	(FT/SEC)	19.800	19.800	19.800
WAVE HEADING	(DEG.)	157.000	157.000	157.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9245E+06	1.9245E+06	1.9245E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.3127E+03	-2.3127E+03	-2.3127E+03
TOTAL ADDED MASS	(SLUGS)	2.9339E+06	2.9339E+06	2.9339E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	8.0071E+04	8.0071E+04	8.0071E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3903E+04	4.3903E+04	4.3903E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2103E+04	1.2103E+04	1.2103E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3608E+05	1.3608E+05	1.3608E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION	(RAD.)	0.032	0.040	0.052
MAGNIFICATION FACTOR	(NON-D.)	2.0188E+00	2.3554E+00	2.8641E+00
F COS(EPS)	(LBS.)	1.8668E+05	-2.3151E+04	-1.6533E+05
F SIN(EPS)	(LBS.)	6.6873E+04	4.1167E+04	-2.9703E+04
F-WAVE EXCITING FORCE	(LBS.)	1.9830E+05	4.7230E+04	1.6797E+05
EPS-FORCE & WAVE	(RAD.)	0.344	2.083	3.319
DEFLECTION AT STERN	(FEET)	3.1752E-02	8.8236E-03	3.8159E-02
EPS1-WAVE & VIBRATION	(RAD.)	-0.312	-2.043	-3.268
M COS(EPS2)	(LBS.)	2.4009E+07	-3.1428E+06	-3.9934E+07
M SIN(EPS2)	(LBS.)	-6.2295E+06	-7.3317E+06	3.0380E+06
M-BENDING MOMENT AMID	(LBS.)	2.4804E+07	7.9769E+06	4.0049E+07
EPS2-WAVE & B.M.	(RAD.)	6.029	4.307	3.066

SHIP/EFF. WAVE LENGTH	(NON-D.)	5.443	5.891	6.347
EFFECTIVE WAVE LENGTH	(FEET)	183.343	169.400	157.240
ENCOUNTER FREQUENCY	(1/SEC.)	1.773	1.873	1.973
RESONANT FREQUENCY	(1/SEC.)	2.073	2.073	2.073
SPEED	(FT/SEC)	19.800	19.800	19.800
WAVE HEADING	(DEG.)	157.000	157.000	157.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9245E+06	1.9245E+06	1.9245E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.3127E+03	-2.3127E+03	-2.3127E+03
TOTAL ADDED MASS	(SLUGS)	2.9339E+06	2.9339E+06	2.9339E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	8.0071E+04	8.0071E+04	8.0071E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3903E+04	4.3903E+04	4.3903E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2103E+04	1.2103E+04	1.2103E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3608E+05	1.3608E+05	1.3608E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION	(RAD.)	0.071	0.110	0.222
MAGNIFICATION FACTOR	(NON-D.)	3.7151E+00	5.4125E+00	1.0360E+01
F COS(EPS)	(LBS.)	-4.4683E+04	1.1255E+05	6.1541E+04
F SIN(EPS)	(LBS.)	-6.3384E+04	-1.5092E+04	5.4954E+04
F-WAVE EXCITING FORCE	(LBS.)	7.7550E+04	1.1356E+05	8.2506E+04
EPS-FORCE & WAVE	(RAD.)	4.098	6.150	0.729
DEFLECTION AT STERN	(FEET)	2.2851E-02	4.8750E-02	6.7793E-02
EPS1-WAVE & VIBRATION	(RAD.)	-4.027	-6.040	-0.506
M COS(EPS2)	(LBS.)	-1.8069E+07	6.4241E+07	9.2809E+07
M SIN(EPS2)	(LBS.)	2.0883E+07	1.8318E+07	-4.8536E+07
M-BENDING MOMENT AMID	(LBS.)	2.7616E+07	6.6802E+07	1.0473E+08
EPS2-WAVE & B.M.	(RAD.)	2.264	0.278	5.801

SHIP/EFF. WAVE LENGTH	(NON-D.)	6.810	7.279	7.755
EFFECTIVE WAVE LENGTH	(FEET)	146.556	137.105	128.695
ENCOUNTER FREQUENCY	(1/SEC.)	2.073	2.173	2.273
RESONANT FREQUENCY	(1/SEC.)	2.073	2.073	2.073
SPEED	(FT/SEC)	19.800	19.800	19.800
WAVE HEADING	(DEG.)	157.000	157.000	157.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9245E+06	1.9245E+06	1.9245E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.3127E+03	-2.3127E+03	-2.3127E+03
TOTAL ADDED MASS	(SLUGS)	2.9339E+06	2.9339E+06	2.9339E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	8.0071E+04	8.0071E+04	8.0071E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3903E+04	4.3903E+04	4.3903E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2103E+04	1.2103E+04	1.2103E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3608E+05	1.3608E+05	1.3608E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION	(RAD.)	1.571	2.909	3.021
MAGNIFICATION FACTOR	(NON-D.)	4.4695E+01	9.8473E+00	4.9080E+00
F COS(EPS)	(LBS.)	-6.8660E+04	-4.8844E+04	4.5017E+04
F SIN(EPS)	(LBS.)	4.6123E+04	-3.4582E+04	-6.1716E+04
F-WAVE EXCITING FORCE	(LBS.)	8.2714E+04	5.9847E+04	7.6390E+04
EPS-FORCE & WAVE	(RAD.)	2.550	3.758	5.343
DEFLECTION AT STERN	(FEET)	2.9322E-01	4.6743E-02	2.9737E-02
EPS1-WAVE & VIBRATION	(RAD.)	-0.979	-0.849	-2.322
M COS(EPS2)	(LBS.)	2.8966E+08	6.0597E+07	-4.1883E+07
M SIN(EPS2)	(LBS.)	-4.1304E+08	-6.5654E+07	-4.7082E+07
M-BENDING MOMENT AMID	(LBS.)	5.0448E+08	8.9344E+07	6.3015E+07
EPS2-WAVE & B.M.	(RAD.)	5.324	5.458	3.985

SHIP/EFF. WAVE LENGTH	(NON-D.)	8.236	8.724	9.216
EFFECTIVE WAVE LENGTH	(FEET)	121.169	114.400	108.285
ENCOUNTER FREQUENCY	(1/SEC.)	2.373	2.473	2.573
RESONANT FREQUENCY	(1/SEC.)	2.073	2.073	2.073
SPEED	(FT/SEC)	19.800	19.800	19.800
WAVE HEADING	(DEG.)	157.000	157.000	157.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9245E+06	1.9245E+06	1.9245E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.3127E+03	-2.3127E+03	-2.3127E+03
TOTAL ADDED MASS	(SLUGS)	2.9339E+06	2.9339E+06	2.9339E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	8.0071E+04	8.0071E+04	8.0071E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3903E+04	4.3903E+04	4.3903E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2103E+04	1.2103E+04	1.2103E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3608E+05	1.3608E+05	1.3608E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION	(RAD.)	3.059	3.079	3.090
MAGNIFICATION FACTOR	(NON-D.)	3.2110E+00	2.3586E+00	1.8475E+00
F COS(EPS)	(LBS.)	2.6207E+04	-3.7197E+04	-2.7871E+03
F SIN(EPS)	(LBS.)	1.5036E+04	6.7943E+04	-1.0121E+03
F-WAVE EXCITING FORCE	(LBS.)	3.0214E+04	7.7459E+04	2.9652E+03
EPS-FORCE & WAVE	(RAD.)	0.521	2.072	3.490
DEFLECTION AT STERN	(FEET)	7.6949E-03	1.4490E-02	4.3450E-04
EPS1-WAVE & VIBRATION	(RAD.)	2.538	1.007	-0.400
M COS(EPS2)	(LBS.)	-1.5046E+07	1.9155E+07	1.1331E+06
M SIN(EPS2)	(LBS.)	9.8607E+06	3.1878E+07	-4.4884E+05
M-BENDING MOMENT AMID	(LBS.)	1.7989E+07	3.7190E+07	1.2187E+06
EPS2-WAVE & B.M.	(RAD.)	2.561	1.030	5.906

SHIP/EFF. WAVE LENGTH	(NON-D.)	9.714	10.217	10.724
EFFECTIVE WAVE LENGTH	(FEET)	102.736	97.682	93.062
ENCOUNTER FREQUENCY	(1/SEC.)	2.673	2.773	2.873
RESONANT FREQUENCY	(1/SEC.)	2.073	2.073	2.073
SPEED	(FT/SEC)	19.800	19.800	19.800
WAVE HEADING	(DEG.)	157.000	157.000	157.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9245E+06	1.9245E+06	1.9245E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.3127E+03	-2.3127E+03	-2.3127E+03
TOTAL ADDED MASS	(SLUGS)	2.9339E+06	2.9339E+06	2.9339E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	8.0071E+04	8.0071E+04	8.0071E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3903E+04	4.3903E+04	4.3903E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2103E+04	1.2103E+04	1.2103E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3608E+05	1.3608E+05	1.3608E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION	(RAD.)	3.098	3.104	3.108
MAGNIFICATION FACTOR	(NON-D.)	1.5077E+00	1.2659E+00	1.0854E+00
F COS(EPS)	(LBS.)	3.7874E+04	-1.9088E+04	-4.1272E+04
F SIN(EPS)	(LBS.)	-7.0479E+04	-7.0562E+03	7.2425E+04
F-WAVE EXCITING FORCE	(LBS.)	8.0011E+04	2.0351E+04	8.3360E+04
EPS-FORCE & WAVE	(RAD.)	5.205	3.496	2.089
DEFLECTION AT STERN	(FEET)	9.5680E-03	2.0434E-03	7.1767E-03
EPS1-WAVE & VIBRATION	(RAD.)	-2.107	-0.392	1.019
M COS(EPS2)	(LBS.)	-1.4328E+07	6.2077E+06	1.2930E+07
M SIN(EPS2)	(LBS.)	-2.5391E+07	-2.4824E+06	2.2079E+07
M-BENDING MOMENT AMID	(LBS.)	2.9154E+07	6.6856E+06	2.5587E+07
EPS2-WAVE & B.M.	(RAD.)	4.199	5.903	1.041

SHIP/EFF. WAVE LENGTH	(NON-D.)	11.236
EFFECTIVE WAVE LENGTH	(FEET)	88.824
ENCOUNTER FREQUENCY	(1/SEC.)	2.973
RESONANT FREQUENCY	(1/SEC.)	2.073
SPEED	(FT/SEC)	19.800
WAVE HEADING	(DEG.)	157.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9245E+06
SHIP MASS	(SLUGS)	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.3127E+03
TOTAL ADDED MASS	(SLUGS)	2.9339E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	8.0071E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3903E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2103E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3608E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046
PHI-FORCE & MOTION	(RAD.)	3.111
MAGNIFICATION FACTOR	(NON-D.)	9.4582E-01
F COS(EPS)	(LBS.)	3.9686E+04
F SIN(EPS)	(LBS.)	9.8871E+03
F-WAVE EXCITING FORCE	(LBS.)	4.0899E+04
EPS-FORCE & WAVE	(RAD.)	0.244
DEFLECTION AT STERN	(FEET)	3.0682E-03
EPS1-WAVE & VIBRATION	(RAD.)	2.867
M COS(EPS2)	(LBS.)	-1.1242E+07
M SIN(EPS2)	(LBS.)	3.0381E+06

SHIP/EFF. WAVE LENGTH	(NON-D.)	1.005	1.303	1.623
EFFECTIVE WAVE LENGTH	(FEET)	992.858	766.146	615.030
ENCOUNTER FREQUENCY	(1/SEC.)	0.580	0.680	0.780
RESONANT FREQUENCY	(1/SEC.)	2.080	2.080	2.080
SPEED	(FT/SEC)	19.800	19.800	19.800
WAVE HEADING	(DEG.)	170.000	170.000	170.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.2947E+03	-2.2947E+03	-2.2947E+03
TOTAL ADDED MASS	(SLUGS)	2.9326E+06	2.9326E+06	2.9326E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3474E+04	4.3474E+04	4.3474E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3511E+05	1.3511E+05	1.3511E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION	(RAD.)	0.007	0.008	0.010
MAGNIFICATION FACTOR	(NON-D.)	1.0843E+00	1.1196E+00	1.1636E+00
F COS(EPS)	(LBS.)	-1.2628E+06	-9.5702E+05	-3.0326E+05
F SIN(EPS)	(LBS.)	-7.1926E+04	1.1926E+04	8.6051E+04
F-WAVE EXCITING FORCE	(LBS.)	1.2649E+06	9.5709E+05	3.1523E+05
EPS-FORCE & WAVE	(RAD.)	3.198	3.129	2.865
DEFLECTION AT STERN	(FEET)	1.0810E-01	8.4458E-02	2.8910E-02
EPS1-WAVE & VIBRATION	(RAD.)	-3.192	-3.121	-2.855
M COS(EPS2)	(LBS.)	-1.0948E+07	-1.5581E+07	-3.2574E+06
M SIN(EPS2)	(LBS.)	-3.2668E+07	-4.2329E+06	2.7375E+06
M-BENDING MOMENT AMID	(LBS.)	3.4453E+07	1.6146E+07	4.2549E+06
EPS2-WAVE & B.M.	(RAD.)	4.389	3.407	2.443

SHIP/EFF. WAVE LENGTH	(NON-D.)	1.963	2.320	2.693
EFFECTIVE WAVE LENGTH	(FEET)	508.515	430.167	370.565
ENCOUNTER FREQUENCY	(1/SEC.)	0.880	0.980	1.080
RESONANT FREQUENCY	(1/SEC.)	2.080	2.080	2.080
SPEED	(FT/SEC)	19.800	19.800	19.800
WAVE HEADING	(DEG.)	170.000	170.000	170.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.2947E+03	-2.2947E+03	-2.2947E+03
TOTAL ADDED MASS	(SLUGS)	2.9326E+06	2.9326E+06	2.9326E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3474E+04	4.3474E+04	4.3474E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3511E+05	1.3511E+05	1.3511E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION	(RAD.)	0.011	0.013	0.016
MAGNIFICATION FACTOR	(NON-D.)	1.2179E+00	1.2852E+00	1.3689E+00
F COS(EPS)	(LBS.)	2.2054E+05	2.5687E+05	-5.2443E+04
F SIN(EPS)	(LBS.)	9.4360E+04	2.8106E+04	-5.5349E+04
F-WAVE EXCITING FORCE	(LBS.)	2.3987E+05	2.5840E+05	7.6248E+04
EPS-FORCE & WAVE	(RAD.)	0.404	0.109	3.954
DEFLECTION AT STERN	(FEET)	2.3026E-02	2.6174E-02	8.2268E-03
EPS1-WAVE & VIBRATION	(RAD.)	-0.393	-0.096	-3.938
M COS(EPS2)	(LBS.)	3.0474E+06	6.6865E+06	-1.6422E+06
M SIN(EPS2)	(LBS.)	1.7282E+06	-4.6233E+05	8.1670E+05
M-BENDING MOMENT AMID	(LBS.)	3.5033E+06	6.7025E+06	1.8341E+06
EPS2-WAVE & B.M.	(RAD.)	0.516	6.214	2.680

SHIP/EFF. WAVE LENGTH	(NON-D.)	3.080	3.481	3.892
EFFECTIVE WAVE LENGTH	(FEET)	323.974	286.730	256.392
ENCOUNTER FREQUENCY	(1/SEC.)	1.180	1.280	1.380
RESONANT FREQUENCY	(1/SEC.)	2.080	2.080	2.080
SPEED	(FT/SEC)	19.800	19.800	19.800
WAVE HEADING	(DEG.)	170.000	170.000	170.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.2947E+03	-2.2947E+03	-2.2947E+03
TOTAL ADDED MASS	(SLUGS)	2.9326E+06	2.9326E+06	2.9326E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3474E+04	4.3474E+04	4.3474E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3511E+05	1.3511E+05	1.3511E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION	(RAD.)	0.019	0.022	0.026
MAGNIFICATION FACTOR	(NON-D.)	1.4743E+00	1.6091E+00	1.7857E+00
F COS(EPS)	(LBS.)	-2.3247E+05	-5.8362E+04	1.8363E+05
F SIN(EPS)	(LBS.)	-8.0183E+04	-2.6291E+04	4.8239E+04
F-WAVE EXCITING FORCE	(LBS.)	2.4591E+05	6.4011E+04	1.8986E+05
EPS-FORCE & WAVE	(RAD.)	3.474	3.565	0.257
DEFLECTION AT STERN	(FEET)	2.8574E-02	8.1182E-03	2.6721E-02
EPS1-WAVE & VIBRATION	(RAD.)	-3.455	-3.543	-0.231
M COS(EPS2)	(LBS.)	-1.2191E+07	-4.0079E+06	1.6991E+07
M SIN(EPS2)	(LBS.)	1.9686E+06	1.7615E+06	-1.8275E+06
M-BENDING MOMENT AMID	(LBS.)	1.2349E+07	4.3779E+06	1.7089E+07
EPS2-WAVE & B.M.	(RAD.)	2.981	2.728	6 176

SHIP/EFF. WAVE LENGTH	(NON-D.)	4.315	4.748	5.189
EFFECTIVE WAVE LENGTH	(FEET)	231.282	210.212	192.321
ENCOUNTER FREQUENCY	(1/SEC.)	1.480	1.580	1.680
RESONANT FREQUENCY	(1/SEC.)	2.080	2.080	2.080
SPEED	(FT/SEC)	19.800	19.800	19.800
WAVE HEADING	(DEG.)	170.000	170.000	170.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.2947E+03	-2.2947E+03	-2.2947E+03
TOTAL ADDED MASS	(SLUGS)	2.9326E+06	2.9326E+06	2.9326E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3474E+04	4.3474E+04	4.3474E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3511E+05	1.3511E+05	1.3511E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION	(RAD.)	0.032	0.040	0.051
MAGNIFICATION FACTOR	(NON-D.)	2.0244E+00	2.3623E+00	2.8728E+00
F COS(EPS)	(LBS.)	1.3802E+05	-9.7499E+04	-1.5232E+05
F SIN(EPS)	(LBS.)	6.5077E+04	7.9354E+03	-5.5858E+04
F-WAVE EXCITING FORCE	(LBS.)	1.5259E+05	9.7822E+04	1.6224E+05
EPS-FORCE & WAVE	(RAD.)	0.441	3.060	3.493
DEFLECTION AT STERN	(FEET)	2.4347E-02	1.8213E-02	3.6735E-02
EPS1-WAVE & VIBRATION	(RAD.)	-0.409	-3.021	-3.442
M COS(EPS2)	(LBS.)	1.8012E+07	-1.5990E+07	-3.7871E+07
M SIN(EPS2)	(LBS.)	-6.9772E+06	-3.2614E+06	9.9724E+06
M-BENDING MOMENT AMID	(LBS.)	1.9316E+07	1.6319E+07	3.9162E+07
EPS2-WAVE & B.M.	(RAD.)	5.914	3.343	2.884

SHIP/EFF. WAVE LENGTH(NON-D.)	5.639	6.098	6.563
EFFECTIVE WAVE LENGTH(FEET)	176.968	163.672	152.062
ENCOUNTER FREQUENCY (1/SEC.)	1.780	1.880	1.980
RESONANT FREQUENCY (1/SEC.)	2.080	2.080	2.080
SPEED (FT/SEC)	19.800	19.800	19.800
WAVE HEADING (DEG.)	170.000	170.000	170.000
HYDRODYNAMIC A.M. (SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS (SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M. (SLUGS)	-2.2947E+03	-2.2947E+03	-2.2947E+03
TOTAL ADDED MASS (SLUGS)	2.9326E+06	2.9326E+06	2.9326E+06
HYDRODYNAMIC DAMPING (SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.(SLUGS/SEC)	4.3474E+04	4.3474E+04	4.3474E+04
STRUCTURAL DAMPING (SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING (SLUGS/SEC)	1.3511E+05	1.3511E+05	1.3511E+05
DAMPING/ADDED MASS (1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION (RAD.)	0.071	0.109	0.221
MAGNIFICATION FACTOR (NON-D.)	3.7268E+00	5.4302E+00	1.0397E+01
F COS(EPS) (LBS.)	2.5534E+04	1.2345E+05	9.2060E+03
F SIN(EPS) (LBS.)	-4.6942E+04	2.5718E+04	6.1912E+04
F-WAVE EXCITING FORCE(LBS.)	5.3438E+04	1.2610E+05	6.2593E+04
EPS-FORCE & WAVE (RAD.)	5.211	0.205	1.423
DEFLECTION AT STERN (FEET)	1.5696E-02	5.3970E-02	5.1292E-02
EPS1-WAVE & VIBRATION(RAD.)	-5.140	-0.096	-1.202
M COS(EPS2) (LBS.)	7.1852E+06	7.4602E+07	3.0905E+07
M SIN(EPS2) (LBS.)	1.7716E+07	-4.6039E+06	-7.3728E+07
M-BENDING MOMENT AMID(LBS.)	1.9118E+07	7.4743E+07	7.9943E+07
EPS2-WAVE & B.M. (RAD.)	1.185	6.222	5.109

SHIP/EFF. WAVE LENGTH(NON-D.)	7.036	7.515	8.000
EFFECTIVE WAVE LENGTH(FEET)	141.850	132.807	124.751
ENCOUNTER FREQUENCY (1/SEC.)	2.080	2.180	2.280
RESONANT FREQUENCY (1/SEC.)	2.080	2.080	2.080
SPEED (FT/SEC)	19.800	19.800	19.800
WAVE HEADING (DEG.)	170.000	170.000	170.000
HYDRODYNAMIC A.M. (SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS (SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M. (SLUGS)	-2.2947E+03	-2.2947E+03	-2.2947E+03
TOTAL ADDED MASS (SLUGS)	2.9326E+06	2.9326E+06	2.9326E+06
HYDRODYNAMIC DAMPING (SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.(SLUGS/SEC)	4.3474E+04	4.3474E+04	4.3474E+04
STRUCTURAL DAMPING (SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING (SLUGS/SEC)	1.3511E+05	1.3511E+05	1.3511E+05
DAMPING/ADDED MASS (1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION (RAD.)	1.571	2.910	3.022
MAGNIFICATION FACTOR (NON-D.)	4.5146E+01	9.8848E+00	4.9259E+00
F COS(EPS) (LBS.)	-8.4645E+04	-1.3829E+04	5.2443E+04
F SIN(EPS) (LBS.)	3.9918E+03	-6.1926E+04	-2.5294E+04
F-WAVE EXCITING FORCE(LBS.)	8.4739E+04	6.3452E+04	5.8224E+04
EPS-FORCE & WAVE (RAD.)	3.094	4.493	5.834
DEFLECTION AT STERN (FEET)	3.0152E-01	4.9434E-02	2.2605E-02
EPS1-WAVE & VIBRATION(RAD.)	-1.524	-1.583	-2.812
M COS(EPS2) (LBS.)	3.5580E+07	9.6286E+05	-4.5342E+07
M SIN(EPS2) (LBS.)	-5.2260E+08	-9.5260E+07	-1.6616E+07
M-BENDING MOMENT AMID(LBS.)	5.2381E+08	9.5265E+07	4.8291E+07
EPS2-WAVE & B.M. (RAD.)	4.780	4.722	3.493

SHIP/EFF. WAVE LENGTH(NON-D.)	8.491	8.988	9.489
EFFECTIVE WAVE LENGTH(FEET)	117.536	111.042	105.170
ENCOUNTER FREQUENCY (1/SEC.)	2.380	2.480	2.580
RESONANT FREQUENCY (1/SEC.)	2.080	2.080	2.080
SPEED (FT/SEC)	19.800	19.800	19.800
WAVE HEADING (DEG.)	170.000	170.000	170.000
HYDRODYNAMIC A.M. (SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS (SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M. (SLUGS)	-2.2947E+03	-2.2947E+03	-2.2947E+03
TOTAL ADDED MASS (SLUGS)	2.9326E+06	2.9326E+06	2.9326E+06
HYDRODYNAMIC DAMPING (SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.(SLUGS/SEC)	4.3474E+04	4.3474E+04	4.3474E+04
STRUCTURAL DAMPING (SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING (SLUGS/SEC)	1.3511E+05	1.3511E+05	1.3511E+05
DAMPING/ADDED MASS (1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION (RAD.)	3.060	3.079	3.091
MAGNIFICATION FACTOR (NON-D.)	3.2227E+00	2.3673E+00	1.8544E+00
F COS(EPS) (LBS.)	2.3776E+03	-2.9208E+04	1.5134E+04
F SIN(EPS) (LBS.)	5.7024E+04	3.8377E+04	-5.2991E+04
F-WAVE EXCITING FORCE(LBS.)	5.7074E+04	4.8228E+04	5.5110E+04
EPS-FORCE & WAVE (RAD.)	1.529	2.221	4.991
DEFLECTION AT STERN (FEET)	1.4497E-02	8.9983E-03	8.0547E-03
EPS1-WAVE & VIBRATION(RAD.)	1.531	0.858	-1.900
M COS(EPS2) (LBS.)	6.2362E+05	1.4895E+07	-6.8226E+06
M SIN(EPS2) (LBS.)	3.4143E+07	1.7899E+07	-2.1626E+07
M-BENDING MOMENT AMID(LBS.)	3.4149E+07	2.3286E+07	2.2677E+07
EPS2-WAVE & B.M. (RAD.)	1.553	0.877	4.407

SHIP/EFF. WAVE LENGTH(NON-D.)	9.996	10.508	11.024
EFFECTIVE WAVE LENGTH(FEET)	99.837	94.977	90.531
ENCOUNTER FREQUENCY (1/SEC.)	2.680	2.780	2.880
RESONANT FREQUENCY (1/SEC.)	2.080	2.080	2.080
SPEED (FT/SEC)	19.800	19.800	19.800
WAVE HEADING (DEG.)	170.000	170.000	170.000
HYDRODYNAMIC A.M. (SLUGS)	1.9232E+06	1.9232E+06	1.9232E+06
SHIP MASS (SLUGS)	1.0117E+06	1.0117E+06	1.0117E+06
SPEED DEPENDENT A.M. (SLUGS)	-2.2947E+03	-2.2947E+03	-2.2947E+03
TOTAL ADDED MASS (SLUGS)	2.9326E+06	2.9326E+06	2.9326E+06
HYDRODYNAMIC DAMPING (SLUGS/SEC)	7.9473E+04	7.9473E+04	7.9473E+04
SPEED DEPENDENT DAMP.(SLUGS/SEC)	4.3474E+04	4.3474E+04	4.3474E+04
STRUCTURAL DAMPING (SLUGS/SEC)	1.2168E+04	1.2168E+04	1.2168E+04
TOTAL DAMPING (SLUGS/SEC)	1.3511E+05	1.3511E+05	1.3511E+05
DAMPING/ADDED MASS (1/SEC.)	0.046	0.046	0.046
PHI-FORCE & MOTION (RAD.)	3.098	3.104	3.108
MAGNIFICATION FACTOR (NON-D.)	1.5134E+00	1.2708E+00	1.0897E+00
F COS(EPS) (LBS.)	1.1772E+04	-3.3228E+04	3.7365E+03
F SIN(EPS) (LBS.)	-4.5542E+04	5.2025E+04	[illegible].8440E+04
F-WAVE EXCITING FORCE(LBS.)	4.7039E+04	6.1731E+04	4.8584E+04
EPS-FORCE & WAVE (RAD.)	4.965	2.139	1.494
DEFLECTION AT STERN (FEET)	5.6109E-03	6.1830E-03	4.1727E-03
EPS1-WAVE & VIBRATION(RAD.)	-1.867	0.965	1.614
M COS(EPS2) (LBS.)	-4.7696E+06	1.1256E+07	-8.2340E+05
M SIN(EPS2) (LBS.)	-1.6562E+07	1.7080E+07	1.4953E+07
M-BENDING MOMENT AMID(LBS.)	1.7235E+07	2.0456E+07	1.4976E+07
EPS2-WAVE & B.M. (RAD.)	4.432	0.988	1.626

SHIP/EFF. WAVE LENGTH	(NON-D.)	11.544
EFFECTIVE WAVE LENGTH	(FEET)	86.450
ENCOUNTER FREQUENCY	(1/SEC.)	2.980
RESONANT FREQUENCY	(1/SEC.)	2.080
SPEED	(FT/SEC)	19.800
WAVE HEADING	(DEG.)	170.000
HYDRODYNAMIC A.M.	(SLUGS)	1.9232E+06
SHIP MASS	(SLUGS)	1.0117E+06
SPEED DEPENDENT A.M.	(SLUGS)	-2.2947E+03
TOTAL ADDED MASS	(SLUGS)	2.9326E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.9473E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.3474E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.2168E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3511E+05
DAMPING/ADDED MASS	(1/SEC.)	0.046
PHI-FORCE & MOTION	(RAD.)	3.111
MAGNIFICATION FACTOR	(NON-D.)	9.4959E-01
F COS(EPS)	(LBS.)	4.8926E+04
F SIN(EPS)	(LBS.)	-5.4342E+04
F-WAVE EXCITING FORCE	(LBS.)	7.3121E+04
EPS-FORCE & WAVE	(RAD.)	5.445
DEFLECTION AT STERN	(FEET)	5.4726E-03
EPS1-WAVE & VIBRATION	(RAD.)	-2.334
M COS(EPS2)	(LBS.)	-1.4164E+07
M SIN(EPS2)	(LBS.)	-1.5508E+07
M-BENDING MOMENT AMID	(LBS.)	2.1003E+07
EPS2-WAVE & B.M.	(RAD.)	3.972

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SHIP DATA FILE NAME? CASE7
OFFSET DATA FILE NAME? OFC02
SPEED? 17.01017.010
FREQ.? 1.00503.0050.1
HEADING? 180.

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SHIP/EFF. WAVE LENGTH(NON-D.)	2.603	3.018	3.448
EFFECTIVE WAVE LENGTH(FEET)	383.337	330.717	289.432
ENCOUNTER FREQUENCY (1/SEC.)	1.005	1.105	1.205
RESONANT FREQUENCY (1/SEC.)	2.205	2.205	2.205
SPEED (FT/SEC)	17.010	17.010	17.010
WAVE HEADING (DEG.)	180.000	180.000	180.000
HYDRODYNAMIC A.M. (SLUGS)	2.3482E+06	2.3482E+06	2.3482E+06
SHIP MASS (SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M. (SLUGS)	-1.1353E+03	-1.1353E+03	-1.1353E+03
TOTAL ADDED MASS (SLUGS)	3.3009E+06	3.3009E+06	3.3009E+06
HYDRODYNAMIC DAMPING (SLUGS/SEC)	7.5469E+04	7.5469E+04	7.5469E+04
SPEED DEPENDENT DAMP.(SLUGS/SEC)	4.8323E+04	4.8323E+04	4.8323E+04
STRUCTURAL DAMPING (SLUGS/SEC)	1.5132E+04	1.5132E+04	1.5132E+04
TOTAL DAMPING (SLUGS/SEC)	1.3892E+05	1.3892E+05	1.3892E+05
DAMPING/ADDED MASS (1/SEC.)	0.042	0.042	0.042
PHI-FORCE & MOTION (RAD.)	0.011	0.013	0.015
MAGNIFICATION FACTOR (NON-D.)	1.2621E+00	1.3352E+00	1.4257E+00
F COS(EPS) (LBS.)	2.2660E+04	-7.8986E+04	1.3316E+04
F SIN(EPS) (LBS.)	1.4081E+05	2.1127E+04	-1.5217E+05
F-WAVE EXCITING FORCE(LBS.)	1.4262E+05	8.1763E+04	1.5275E+05
EPS-FORCE & WAVE (RAD.)	1.411	2.880	4.800
DEFLECTION AT STERN (FEET)	1.1216E-02	6.8025E-03	1.3569E-02
EPS1-WAVE & VIBRATION(RAD.)	-1.400	-2.867	-4.785
M COS(EPS2) (LBS.)	1.0451E+06	-2.5212E+06	4.1562E+05
M SIN(EPS2) (LBS.)	-3.1364E+06	-9.1904E+05	7.0247E+06
M-BENDING MOMENT AMID(LBS.)	3.3060E+06	2.6834E+06	7.0370E+06
EPS2-WAVE & B.M. (RAD.)	5.034	3.491	1.512

SHIP/EFF. WAVE LENGTH(NON-D.)	3.893	4.352	4.823
EFFECTIVE WAVE LENGTH(FEET)	256.333	229.311	206.906
ENCOUNTER FREQUENCY (1/SEC.)	1.305	1.405	1.505
RESONANT FREQUENCY (1/SEC.)	2.205	2.205	2.205
SPEED (FT/SEC)	17.010	17.010	17.010
WAVE HEADING (DEG.)	180.000	180.000	180.000
HYDRODYNAMIC A.M. (SLUGS)	2.3482E+06	2.3482E+06	2.3482E+06
SHIP MASS (SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M. (SLUGS)	-1.1353E+03	-1.1353E+03	-1.1353E+03
TOTAL ADDED MASS (SLUGS)	3.3009E+06	3.3009E+06	3.3009C+06
HYDRODYNAMIC DAMPING (SLUGS/SEC)	7.5469E+04	7.5469E+04	7.5469E+04
SPEED DEPENDENT DAMP.(SLUGS/SEC)	4.8323E+04	4.8323E+04	4.8323E+04
STRUCTURAL DAMPING (SLUGS/SEC)	1.5132E+04	1.5132E+04	1.5132E+04
TOTAL DAMPING (SLUGS/SEC)	1.3892E+05	1.3892E+05	1.3892E+05
DAMPING/ADDED MASS (1/SEC.)	0.042	0.042	0.042
PHI-FORCE & MOTION (RAD.)	0.017	0.020	0.024
MAGNIFICATION FACTOR (NON-D.)	1.5389E+00	1.6832E+00	1.8716E+00
F COS(EPS) (LBS.)	1.0560E+05	6.4012E+03	-8.6394E+04
F SIN(EPS) (LBS.)	-1.2465E+05	9.9465E+04	1.8079E+05
F-WAVE EXCITING FORCE(LBS.)	1.6337E+05	9.9671E+04	2.0037E+05
EPS-FORCE & WAVE (RAD.)	5.415	1.507	2.017
DEFLECTION AT STERN (FEET)	1.5665E-02	1.0453E-02	2.3367E-02
EPS1-WAVE & VIBRATION(RAD.)	-5.398	-1.486	-1.992
M COS(EPS2) (LBS.)	6.1149E+06	6.5792E+05	-8.5942E+06
M SIN(EPS2) (LBS.)	7.8572E+06	-8.3756E+06	-1.9696E+07
M-BENDING MOMENT AMID(LBS.)	9.9563E+06	8.4014E+06	2.1489E+07
EPS2-WAVE & B.M. (RAD.)	0.909	4.791	4.301

SHIP/EFF. WAVE LENGTH	(NON-D.)	5.306	5.800	6.303
EFFECTIVE WAVE LENGTH	(FEET)	188.079	172.074	158.328
ENCOUNTER FREQUENCY	(1/SEC.)	1.605	1.705	1.805
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	17.010	17.010	17.010
WAVE HEADING	(DEG.)	180.000	180.000	180.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3482E+06	2.3482E+06	2.3482E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-1.1353E+03	-1.1353E+03	-1.1353E+03
TOTAL ADDED MASS	(SLUGS)	3.3009E+06	3.3009E+06	3.3009E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.5469E+04	7.5469E+04	7.5469E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.8323E+04	4.8323E+04	4.8323E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5132E+04	1.5132E+04	1.5132E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3892E+05	1.3892E+05	1.38920
DAMPING/ADDED MASS	(1/SEC.)	0.042	0.042	0.042
PHI-FORCE & MOTION	(RAD.)	0.030	0.037	0.047
MAGNIFICATION FACTOR	(NON-D.)	2.1259E+00	2.4853E+00	3.0278E+00
F COS(EPS)	(LBS.)	2.3473E+04	1.1544E+05	-4.6624E+03
F SIN(EPS)	(LBS.)	-3.4921E+04	-1.9367E+05	-8.2581E+03
F-WAVE EXCITING FORCE	(LBS.)	4.2076E+04	2.2547E+05	9.4833E+03
EPS-FORCE & WAVE	(RAD.)	5.304	5.250	4.198
DEFLECTION AT STERN	(FEET)	5.5737E-03	3.4916E-02	1.7891E-03
EPS1-WAVE & VIBRATION	(RAD.)	-5.275	-5.213	-4.151
M COS(EPS2)	(LBS.)	3.4304E+06	2.1394E+07	-1.5564E+06
M SIN(EPS2)	(LBS.)	5.4967E+06	3.8525E+07	2.1421E+06
M-BENDING MOMENT AMID	(LBS.)	6.4793E+06	4.4066E+07	2.6478E+06
EPS2-WAVE & B.M.	(RAD.)	1.013	1.064	2.199

SHIP/EFF. WAVE LENGTH	(NON-D.)	6.816	7.338	7.868
EFFECTIVE WAVE LENGTH	(FEET)	146.414	136.005	126.845
ENCOUNTER FREQUENCY	(1/SEC.)	1.905	2.005	2.105
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	17.010	17.010	17.010
WAVE HEADING	(DEG.)	180.000	180.000	180.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3482E+06	2.3482E+06	2.3482E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-1.1353E+03	-1.1353E+03	-1.1353E+03
TOTAL ADDED MASS	(SLUGS)	3.3009E+06	3.3009E+06	3.3009E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.5469E+04	7.5469E+04	7.5469E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.8323E+04	4.8323E+04	4.8323E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5132E+04	1.5132E+04	1.5132E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3892E+05	1.3892E+05	1.3892E+05
DAMPING/ADDED MASS	(1/SEC.)	0.042	0.042	0.042
PHI-FORCE & MOTION	(RAD.)	0.065	0.100	0.203
MAGNIFICATION FACTOR	(NON-D.)	3.9349E+00	5.7456E+00	1.1050E+01
F COS(EPS)	(LBS.)	-8.2343E+04	4.8946E+04	9.4776E+04
F SIN(EPS)	(LBS.)	1.8523E+05	2.2013E+04	-1.7037E+05
F-WAVE EXCITING FORCE	(LBS.)	2.0271E+05	5.3668E+04	1.9496E+05
EPS-FORCE & WAVE	(RAD.)	1.989	0.423	5.229
DEFLECTION AT STERN	(FEET)	4.9700E-02	1.9213E-02	1.3423E-01
EPS1-WAVE & VIBRATION	(RAD.)	-1.924	-0.323	-5.017
M COS(EPS2)	(LBS.)	-2.8118E+07	3.5434E+07	8.1917E+07
M SIN(EPS2)	(LBS.)	-7.6109E+07	-9.9544E+06	2.6256E+08
M-BENDING MOMENT AMID	(LBS.)	8.1137E+07	3.6806E+07	2.7504E+08
EPS2-WAVE & B.M.	(RAD.)	4.358	6.009	1.268

SHIP/EFF. WAVE LENGTH	(NON-D.)	8.406	8.950	9.502
EFFECTIVE WAVE LENGTH	(FEET)	118.732	111.502	105.026
ENCOUNTER FREQUENCY	(1/SEC.)	2.205	2.305	2.405
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	17.010	17.010	17.010
WAVE HEADING	(DEG.)	180.000	180.000	180.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3482E+06	2.3482E+06	2.3482E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-1.1353E+03	-1.1353E+03	-1.1353E+03
TOTAL ADDED MASS	(SLUGS)	3.3009E+06	3.3009E+06	3.3009E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.5469E+04	7.5469E+04	7.5469E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.8323E+04	4.8323E+04	4.8323E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5132E+04	1.5132E+04	1.5132E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3892E+05	1.3892E+05	1.3892E+05
DAMPING/ADDED MASS	(1/SEC.)	0.042	0.042	0.042
PHI-FORCE & MOTION	(RAD.)	1.571	2.930	3.032
MAGNIFICATION FACTOR	(NON-D.)	5.2392E+01	1.0539E+01	5.2419E+00
F COS(EPS)	(LBS.)	-4.6725E+04	-5.0435E+04	8.1118E+04
F SIN(EPS)	(LBS.)	-1.0919E+04	1.5126E+05	-1.8289E+04
F-WAVE EXCITING FORCE	(LBS.)	4.7984E+04	1.5944E+05	8.3154E+04
EPS-FORCE & WAVE	(RAD.)	3.371	1.893	6.061
DEFLECTION AT STERN	(FEET)	1.5664E-01	1.0471E-01	2.7159E-02
EPS1-WAVE & VIBRATION	(RAD.)	-1.800	1.037	-3.029
M COS(EPS2)	(LBS.)	-8.2295E+07	1.2922E+08	-7.3879E+07
M SIN(EPS2)	(LBS.)	-3.5848E+08	2.3794E+08	-9.8055E+06
M-BENDING MOMENT AMID	(LBS.)	3.6781E+08	2.7076E+08	7.4527E+07
EPS2-WAVE & B.M.	(RAD.)	4.487	1.073	3.274

SHIP/EFF. WAVE LENGTH	(NON-D.)	10.061	10.626	11.196
EFFECTIVE WAVE LENGTH	(FEET)	99.196	93.924	89.136
ENCOUNTER FREQUENCY	(1/SEC.)	2.505	2.605	2.705
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	17.010	17.010	17.010
WAVE HEADING	(DEG.)	180.000	180.000	180.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3482E+06	2.3482E+06	2.3482E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-1.1353E+03	-1.1353E+03	-1.1353E+03
TOTAL ADDED MASS	(SLUGS)	3.3009E+06	3.3009E+06	3.3009E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.5469E+04	7.5469E+04	7.5469E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.8323E+04	4.8323E+04	4.8323E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5132E+04	1.5132E+04	1.5132E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3892E+05	1.3892E+05	1.3892E+05
DAMPING/ADDED MASS	(1/SEC.)	0.042	0.042	0.042
PHI-FORCE & MOTION	(RAD.)	3.067	3.085	3.095
MAGNIFICATION FACTOR	(NON-D.)	3.4314E+00	2.5229E+00	1.9783E+00
F COS(EPS)	(LBS.)	2.9896E+04	-6.7522E+04	3.1388E+04
F SIN(EPS)	(LBS.)	-1.2390E+05	5.6243E+04	8.4065E+04
F-WAVE EXCITING FORCE	(LBS.)	1.2746E+05	8.7878E+04	8.9734E+04
EPS-FORCE & WAVE	(RAD.)	4.949	2.447	1.213
DEFLECTION AT STERN	(FEET)	2.7251E-02	1.3815E-02	1.1061E-02
EPS1-WAVE & VIBRATION	(RAD.)	-1.882	0.638	1.882
M COS(EPS2)	(LBS.)	-2.3940E+07	3.5752E+07	-1.2588E+07
M SIN(EPS2)	(LBS.)	-8.0920E+07	2.8125E+07	3.8039E+07
M-BENDING MOMENT AMID	(LBS.)	8.4387E+07	4.5489E+07	4.0068E+07
EPS2-WAVE & B.M.	(RAD.)	4.425	0.667	1.890

SHIP/EFF. WAVE LENGTH	(NON-D.)	11.773	12.355	12.941
EFFECTIVE WAVE LENGTH	(FEET)	84.772	80.780	77.116
ENCOUNTER FREQUENCY	(1/SEC.)	2.805	2.905	3.005
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	17.010	17.010	17.010
WAVE HEADING	(DEG.)	180.000	180.000	180.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3482E+06	2.3482E+C6	2.3482E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-1.1353E+03	-1.1353E+03	-1.1353E+03
TOTAL ADDED MASS	(SLUGS)	3.3009E+06	3.3009E+06	3.3009E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.5469E+04	7.5469E+04	7.5469E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	4.8323E+04	4.8323E+04	4.8323E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5132E+04	1.5132E+04	1.5132E+04
TOTAL DAMPING	(SLUGS/SEC)	1.3892E+05	1.3892E+05	1.3892E+05
DAMPING/ADDED MASS	(1/SEC.)	0.042	0.042	0.042
PHI-FORCE & MOTION	(RAD.)	3.102	3.107	3.111
MAGNIFICATION FACTOR	(NON-D.)	1.6162E+00	1.3585E+00	1.1660E+00
F COS(EPS)	(LBS.)	6.0920E+04	-6.1202E+04	-5.2379E+03
F SIN(EPS)	(LBS.)	-8.7064E+04	-2.7919E+04	9.5746E+04
F-WAVE EXCITING FORCE	(LBS.)	1.0626E+05	6.7270E+04	9.5889E+04
EPS-FORCE & WAVE	(RAD.)	5.323	3.570	1.625
DEFLECTION AT STERN	(FEET)	1.0701E-02	5.6940E-03	6.9664E-03
EPS1-WAVE & VIBRATION	(RAD.)	-2.221	-0.462	1.486
M COS(EPS2)	(LBS.)	-2.4285E+07	2.1272E+07	2.1646E+06
M SIN(EPS2)	(LBS.)	-3.3839E+07	-1.0349E+07	3.1490E+07
M-BENDING MOMENT AMID	(LBS.)	4.1651E+07	2.3656E+07	3.1564E+07
EPS2-WAVE & B.M.	(RAD.)	4.090	5.830	1.502

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SPM2G163  18 DEC 80  14:23

SHIP DATA FILE NAME? CASE8
OFFSET DATA FILE NAME? OFCOR3
SPEED? 17.01017.010
FREQ.? 1.50503.0050.1
HEADING? 160.
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SHIP/EFF. WAVE LENGTH	(NON-D.)	4.677	5.149	5.632
EFFECTIVE WAVE LENGTH	(FEET)	213.373	193.813	177.197
ENCOUNTER FREQUENCY	(1/SEC.)	1.505	1.605	1.705
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	17.010	17.010	17.010
WAVE HEADING	(DEG.)	160.000	160.000	160.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-3.6336E+03	-3.6336E+03	-3.6336E+03
TOTAL ADDED MASS	(SLUGS)	3.3094E+06	3.3094E+06	3.3094E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.1679E+04	7.1679E+04	7.1679E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	1.4039E+04	1.4039E+04	1.4039E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING	(SLUGS/SEC)	1.0090E+05	1.0090E+05	1.0090E+05
DAMPING/ADDED MASS	(1/SEC.)	0.030	0.030	0.030
PHI-FORCE & MOTION	(RAD.)	0.018	0.021	0.027
MAGNIFICATION FACTOR	(NON-D.)	1.8719E+00	2.1264E+00	2.4861E+00
F COS(EPS)	(LBS.)	-1.3304E+05	5.1931E+04	1.6092E+05
F SIN(EPS)	(LBS.)	1.6307E+05	8.8966E+04	-1.2923E+05
F-WAVE EXCITING FORCE	(LBS.)	2.1045E+05	1.0301E+05	2.0639E+05
EPS-FORCE & WAVE	(RAD.)	2.255	2.099	5.607
DEFLECTION AT STERN	(FEET)	2.4483E-02	1.3613E-02	3.1088E-02
EPS1-WAVE & VIBRATION	(RAD.)	-2.237	-2.078	-5.580
M COS(EPS2)	(LBS.)	-1.4273E+07	-6.2281E+06	3.1664E+07
M SIN(EPS2)	(LBS.)	-1.8365E+07	-1.2669E+07	2.7492E+07
M-BENDING MOMENT AMID	(LBS.)	2.3259E+07	1.4117E+07	4.1933E+07
EPS2-WAVE & B.M.	(RAD.)	4.052	4.255	0.715

SHIP/EFF. WAVE LENGTH	(NON-D.)	6.125	6.628	7.139
EFFECTIVE WAVE LENGTH	(FEET)	162.936	150.584	139.800
ENCOUNTER FREQUENCY	(1/SEC.)	1.805	1.905	2.005
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	17.010	17.010	17.010
WAVE HEADING	(DEG.)	160.000	160.000	160.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-3.6336E+03	-3.6336E+03	-3.6336E+03
TOTAL ADDED MASS	(SLUGS)	3.3094E+06	3.3094E+06	3.3094E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.1679E+04	7.1679E+04	7.1679E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	1.4039E+04	1.4039E+04	1.4039E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING	(SLUGS/SEC)	1.0090E+05	1.0090E+05	1.0090E+05
DAMPING/ADDED MASS	(1/SEC.)	0.030	0.030	0.030
PHI-FORCE & MOTION	(RAD.)	0.034	0.047	0.072
MAGNIFICATION FACTOR	(NON-D.)	3.0294E+00	3.9389E+00	5.7592E+00
F COS(EPS)	(LBS.)	9.8298E+04	-1.2551E+05	-7.1470E+04
F SIN(EPS)	(LBS.)	-1.3223E+05	8.7214E+04	1.4192E+05
F-WAVE EXCITING FORCE	(LBS.)	1.6477E+05	1.5284E+05	1.5890E+05
EPS-FORCE & WAVE	(RAD.)	5.352	2.534	2.037
DEFLECTION AT STERN	(FEET)	3.1021E-02	3.7414E-02	5.6874E-02
EPS1-WAVE & VIBRATION	(RAD.)	-5.317	-2.487	-1.965
M COS(EPS2)	(LBS.)	2.3713E+07	-4.9567E+07	-3.6308E+07
M SIN(EPS2)	(LBS.)	3.6046E+07	-3.9729E+07	-9.4322E+07
M-BENDING MOMENT AMID	(LBS.)	4.3146E+07	6.3524E+07	1.0110E+08
EPS2-WAVE & B.M.	(RAD.)	0.989	3.817	4.344

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SHIP/EFF. WAVE LENGTH(NON-D.)	7.658	8.186	8.721
EFFECTIVE WAVE LENGTH(FEET)	130.314	121.917	114.439
ENCOUNTER FREQUENCY (1/SEC.)	2.105	2.205	2.305
RESONANT FREQUENCY (1/SEC.)	2.205	2.205	2.205
SPEED (FT/SEC)	17.010	17.010	17.010
WAVE HEADING (DEG.)	160.000	160.000	160.000
HYDRODYNAMIC A.M. (SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS (SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M. (SLUGS)	-3.6336E+03	-3.6336E+03	-3.6336E+03
TOTAL ADDED MASS (SLUGS)	3.3094E+06	3.3094E+06	3.3094E+06
HYDRODYNAMIC DAMPING (SLUGS/SEC)	7.1679E+04	7.1679E+04	7.1679E+04
SPEED DEPENDENT DAMP.(SLUGS/SEC)	1.4039E+04	1.4039E+04	1.4039E+04
STRUCTURAL DAMPING (SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING (SLUGS/SEC)	1.0090E+05	1.0090E+05	1.0090E+05
DAMPING/ADDED MASS (1/SEC.)	0.030	0.030	0.030
PHI-FORCE & MOTION (RAD.)	0.148	1.571	2.987
MAGNIFICATION FACTOR (NON-D.)	1.1158E+01	7.2321E+01	1.0652E+01
F COS(EPS) (LBS.)	1.4585E+05	8.3440E+04	-1.1682E+05
F SIN(EPS) (LBS.)	-5.6081E+04	-1.3011E+05	3.9397E+04
F-WAVE EXCITING FORCE(LBS.)	1.5626E+05	1.5457E+05	1.2329E+05
EPS-FORCE & WAVE (RAD.)	5.916	5.283	2.816
DEFLECTION AT STERN (FEET)	1.0836E-01	6.9474E-01	8.1618E-02
EPS1-WAVE & VIBRATION(RAD.)	-5.768	-3.712	0.171
M COS(EPS2) (LBS.)	1.9668E+08	-1.3523E+09	1.9527E+08
M SIN(EPS2) (LBS.)	1.1863E+08	7.5530E+08	4.1135E+07
M-BENDING MOMENT AMID(LBS.)	2.2969E+08	1.5490E+09	1.9956E+08
EPS2-WAVE & B.M. (RAD.)	0.543	2.632	0.208

SHIP/EFF. WAVE LENGTH(NON-D.)	9.263	9.811	10.366
EFFECTIVE WAVE LENGTH(FEET)	107.743	101.718	96.273
ENCOUNTER FREQUENCY (1/SEC.)	2.405	2.505	2.605
RESONANT FREQUENCY (1/SEC.)	2.205	2.205	2.205
SPEED (FT/SEC)	17.010	17.010	17.010
WAVE HEADING (DEG.)	160.000	160.000	160.000
HYDRODYNAMIC A.M. (SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS (SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M. (SLUGS)	-3.6336E+03	-3.6336E+03	-3.6336E+03
TOTAL ADDED MASS (SLUGS)	3.3094E+06	3.3094E+06	3.3094E+06
HYDRODYNAMIC DAMPING (SLUGS/SEC)	7.1679E+04	7.1679E+04	7.1679E+04
SPEED DEPENDENT DAMP.(SLUGS/SEC)	1.4039E+04	1.4039E+04	1.4039E+04
STRUCTURAL DAMPING (SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING (SLUGS/SEC)	1.0090E+05	1.0090E+05	1.0090E+05
DAMPING/ADDED MASS (1/SEC.)	0.030	0.030	0.030
PHI-FORCE & MOTION (RAD.)	3.062	3.088	3.100
MAGNIFICATION FACTOR (NON-D.)	5.2567E+00	3.4359E+00	2.5249E+00
F COS(EPS) (LBS.)	-4.2340E+04	1.1886E+05	2.8242E+04
F SIN(EPS) (LBS.)	1.0507E+05	-3.4257E+04	-7.2447E+04
F-WAVE EXCITING FORCE(LBS.)	1.1328E+05	1.2370E+05	7.7750E+04
EPS-FORCE & WAVE (RAD.)	1.954	6.003	5.084
DEFLECTION AT STERN (FEET)	3.7008E-02	2.6414E-02	1.2202E-02
EPS1-WAVE & VIBRATION(RAD.)	1.108	-2.915	-1.984
M COS(EPS2) (LBS.)	4.1868E+07	-7.5248E+07	-1.4780E+07
M SIN(EPS2) (LBS.)	9.4617E+07	-2.0210E+07	-3.7477E+07
M-BENDING MOMENT AMID(LBS.)	1.0347E+08	7.7915E+07	4.0286E+07
EPS2-WAVE & B.M. (RAD.)	1.154	3.404	4.337

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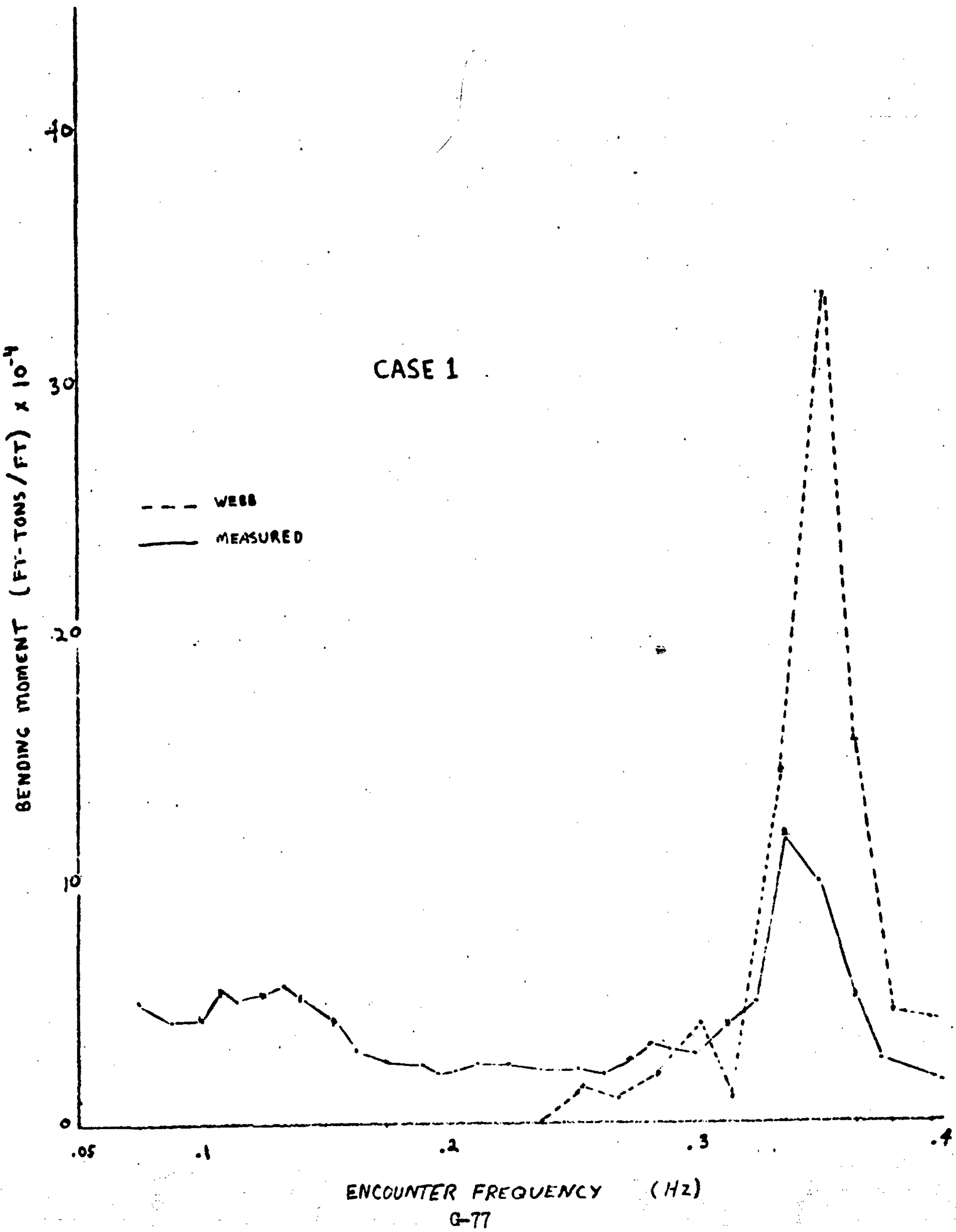
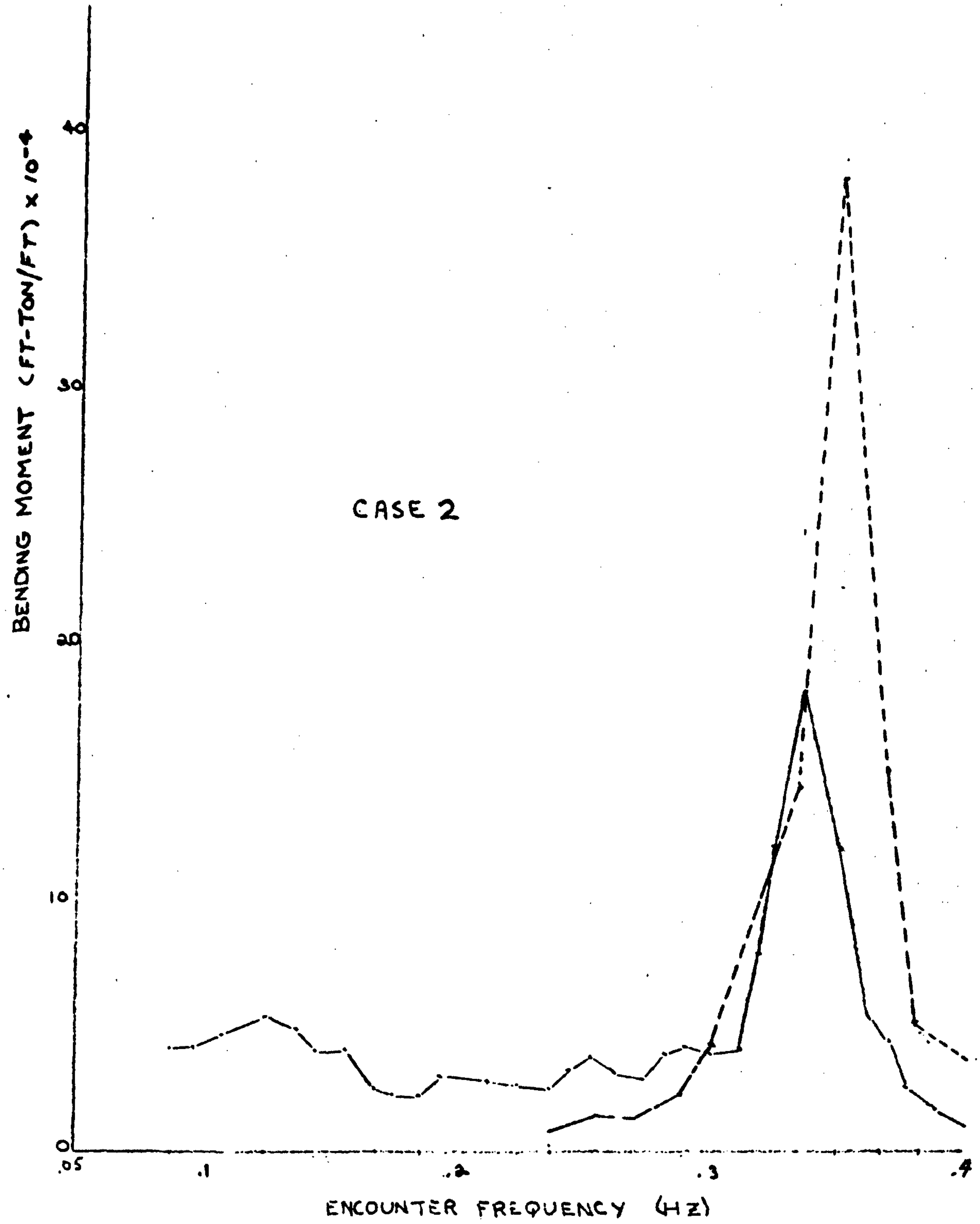
SHIP/EFF. WAVE LENGTH	(NON-D.)	10.927	11.494	12.067
EFFECTIVE WAVE LENGTH	(FEET)	91.330	86.826	82.708
ENCOUNTER FREQUENCY	(1/SEC.)	2.705	2.805	2.905
RESONANT FREQUENCY	(1/SEC.)	2.205	2.205	2.205
SPEED	(FT/SEC)	17.010	17.010	17.010
WAVE HEADING	(DEG.)	160.000	160.000	160.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3593E+06	2.3593E+06	2.3593E+06
SHIP MASS	(SLUGS)	9.5377E+05	9.5377E+05	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-3.6336E+03	-3.6336E+03	-3.6336E+03
TOTAL ADDED MASS	(SLUGS)	3.3094E+06	3.3094E+06	3.3094E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.1679E+04	7.1679E+04	7.1679E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	1.4039E+04	1.4039E+04	1.4039E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5182E+04	1.5182E+04	1.5182E+04
TOTAL DAMPING	(SLUGS/SEC)	1.0090E+05	1.0090E+05	1.0090E+05
DAMPING/ADDED MASS	(1/SEC.)	0.030	0.030	0.030
PHI-FORCE & MOTION	(RAD.)	3.108	3.113	3.117
MAGNIFICATION FACTOR	(NON-D.)	1.9793E+00	1.6168E+00	1.3508E+00
F COS(EPS)	(LBS.)	-7.9483E+04	1.4464E+04	5.6215E+04
F SIN(EPS)	(LBS.)	3.4695E+04	3.8748E+04	-3.0725E+04
F-WAVE EXCITING FORCE	(LBS.)	8.6726E+04	4.1360E+04	6.4064E+04
EPS-FORCE & WAVE	(RAD.)	2.730	1.214	5.783
DEFLECTION AT STERN	(FEET)	1.0668E-02	4.1559E-03	5.4101E-03
EPS1-WAVE & VIBRATION	(RAD.)	0.378	1.900	-2.666
M COS(EPS2)	(LBS.)	3.4249E+07	-5.5317E+06	-1.9379E+07
M SIN(EPS2)	(LBS.)	1.5011E+07	1.4976E+07	-1.0784E+07
M-BENDING MOMENT AMID	(LBS.)	3.7394E+07	1.5965E+07	2.2177E+07
EPS2-WAVE & B.M.	(RAD.)	0.413	1.925	3.649

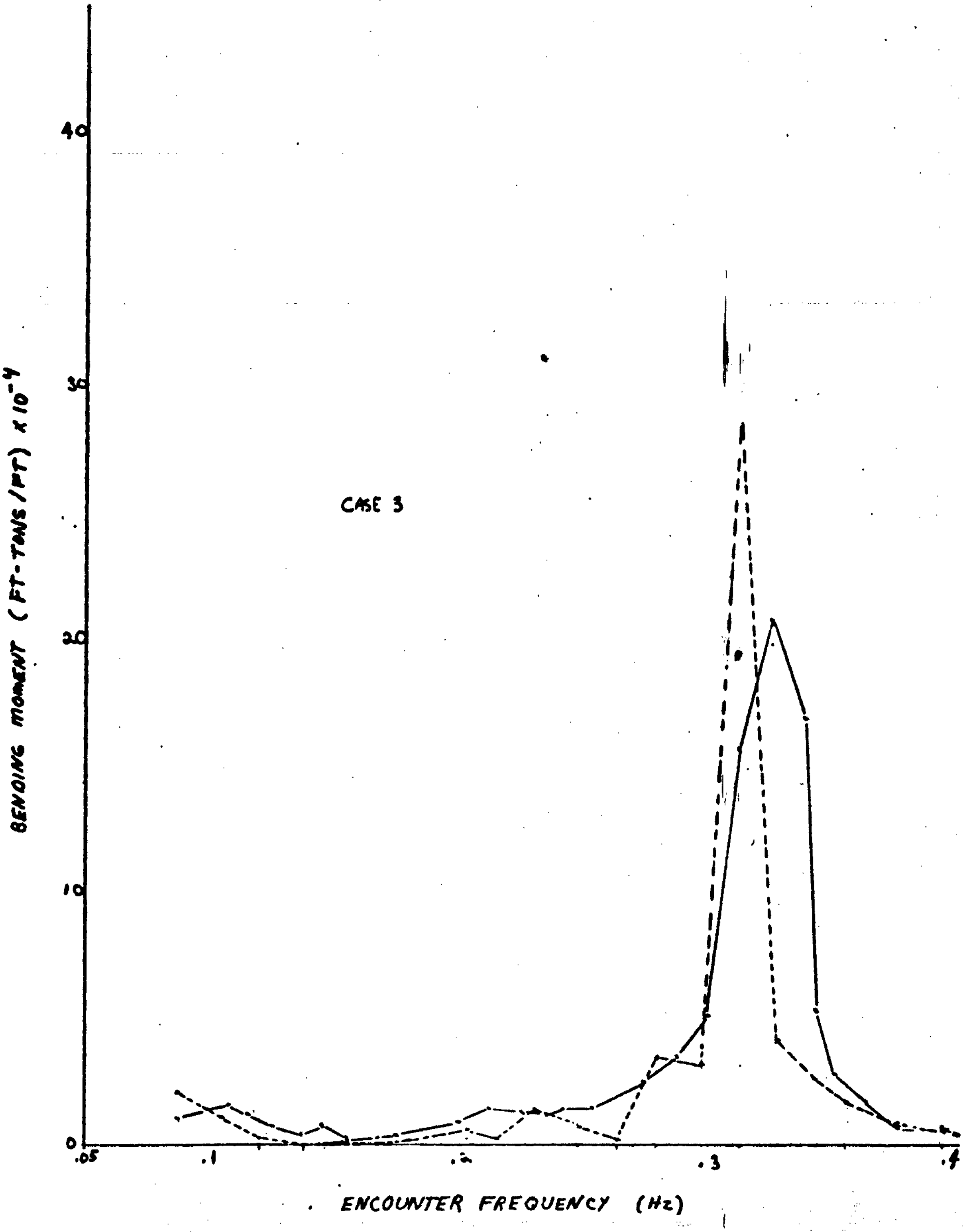
SHIP/EFF. WAVE LENGTH	(NON-D.)	12.644
EFFECTIVE WAVE LENGTH	(FEET)	78.930
ENCOUNTER FREQUENCY	(1/SEC.)	3.005
RESONANT FREQUENCY	(1/SEC.)	2.205
SPEED	(FT/SEC)	17.010
WAVE HEADING	(DEG.)	160.000
HYDRODYNAMIC A.M.	(SLUGS)	2.3593E+06
SHIP MASS	(SLUGS)	9.5377E+05
SPEED DEPENDENT A.M.	(SLUGS)	-3.6336E+03
TOTAL ADDED MASS	(SLUGS)	3.3094E+06
HYDRODYNAMIC DAMPING	(SLUGS/SEC)	7.1679E+04
SPEED DEPENDENT DAMP.	(SLUGS/SEC)	1.4039E+04
STRUCTURAL DAMPING	(SLUGS/SEC)	1.5182E+04
TOTAL DAMPING	(SLUGS/SEC)	1.0090E+05
DAMPING/ADDED MASS	(1/SEC.)	0.030
PHI-FORCE & MOTION	(RAD.)	3.120
MAGNIFICATION FACTOR	(NON-D.)	1.1662E+00
F COS(EPS)	(LBS.)	-2.3114E+04
F SIN(EPS)	(LBS.)	-7.9375E+03
F-WAVE EXCITING FORCE	(LBS.)	2.4439E+04
EPS-FORCE & WAVE	(RAD.)	3.472
DEFLECTION AT STERN	(FEET)	1.7713E-03
EPS1-WAVE & VIBRATION	(RAD.)	-0.353
M COS(EPS2)	(LBS.)	7.3933E+06
M SIN(EPS2)	(LBS.)	-2.5214E+06
M-BENDING MOMENT AMID	(LBS.)	7.8114E+06
EPS2-WAVE & B.M.	(RAD.)	5.955

134.715 CRU
READY

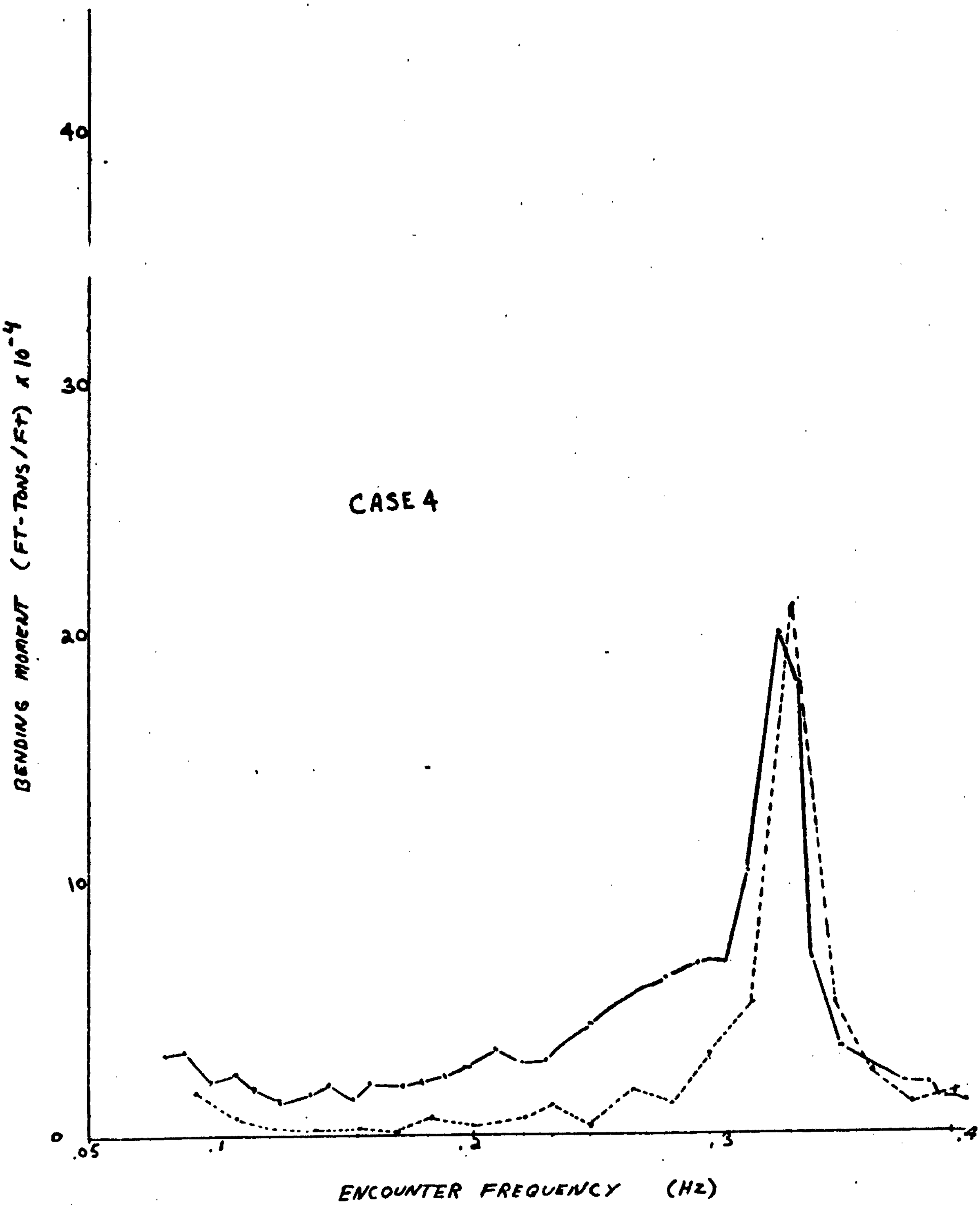
OLD CASE8
READY

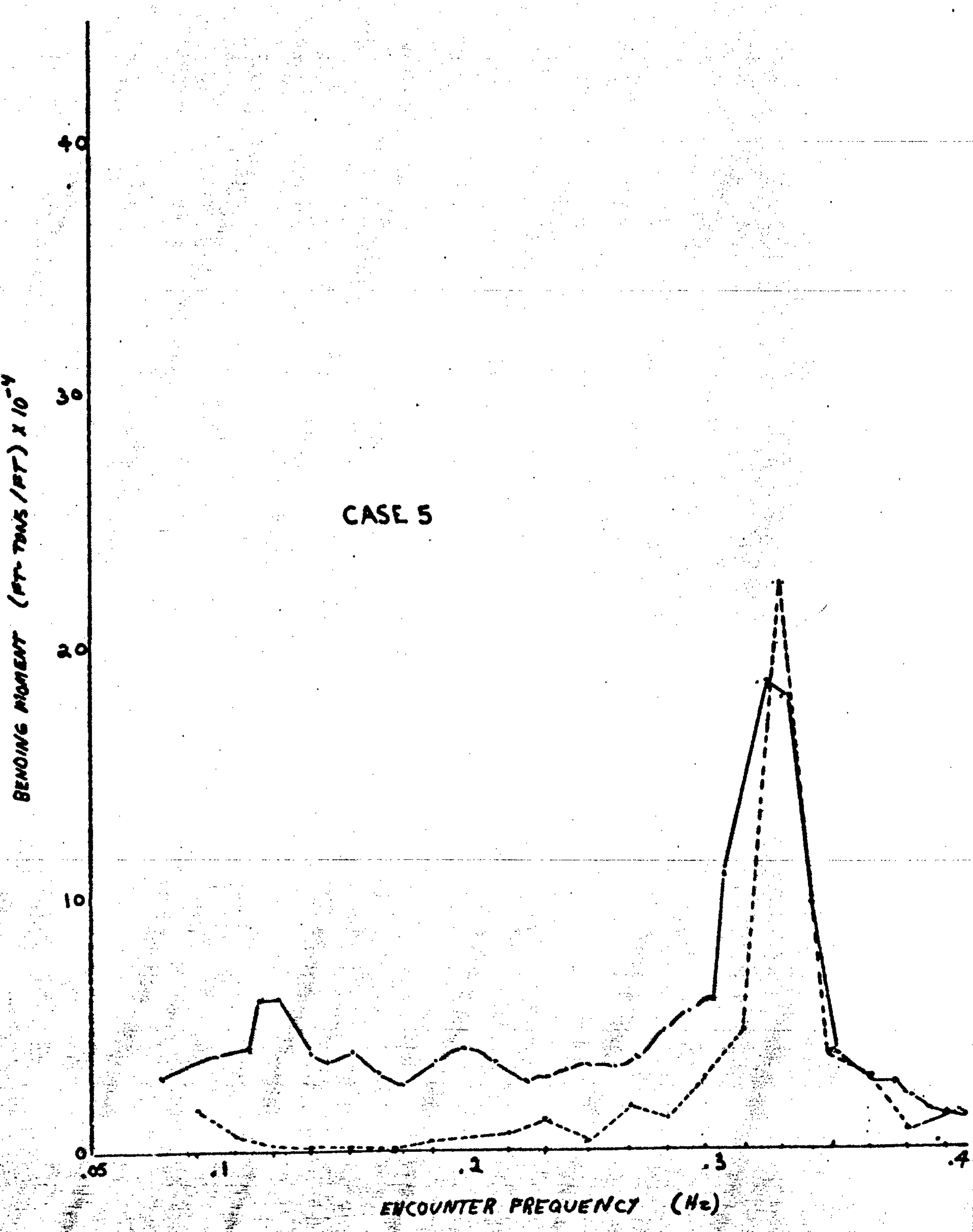

CASE 1
WEBB
MEASURED
BENDING MOMENT (FT-TONS/FT) x 10⁻⁴
40
30
20
10
0
.05
.1
.2
.3
.4
ENCOUNTER FREQUENCY (Hz)

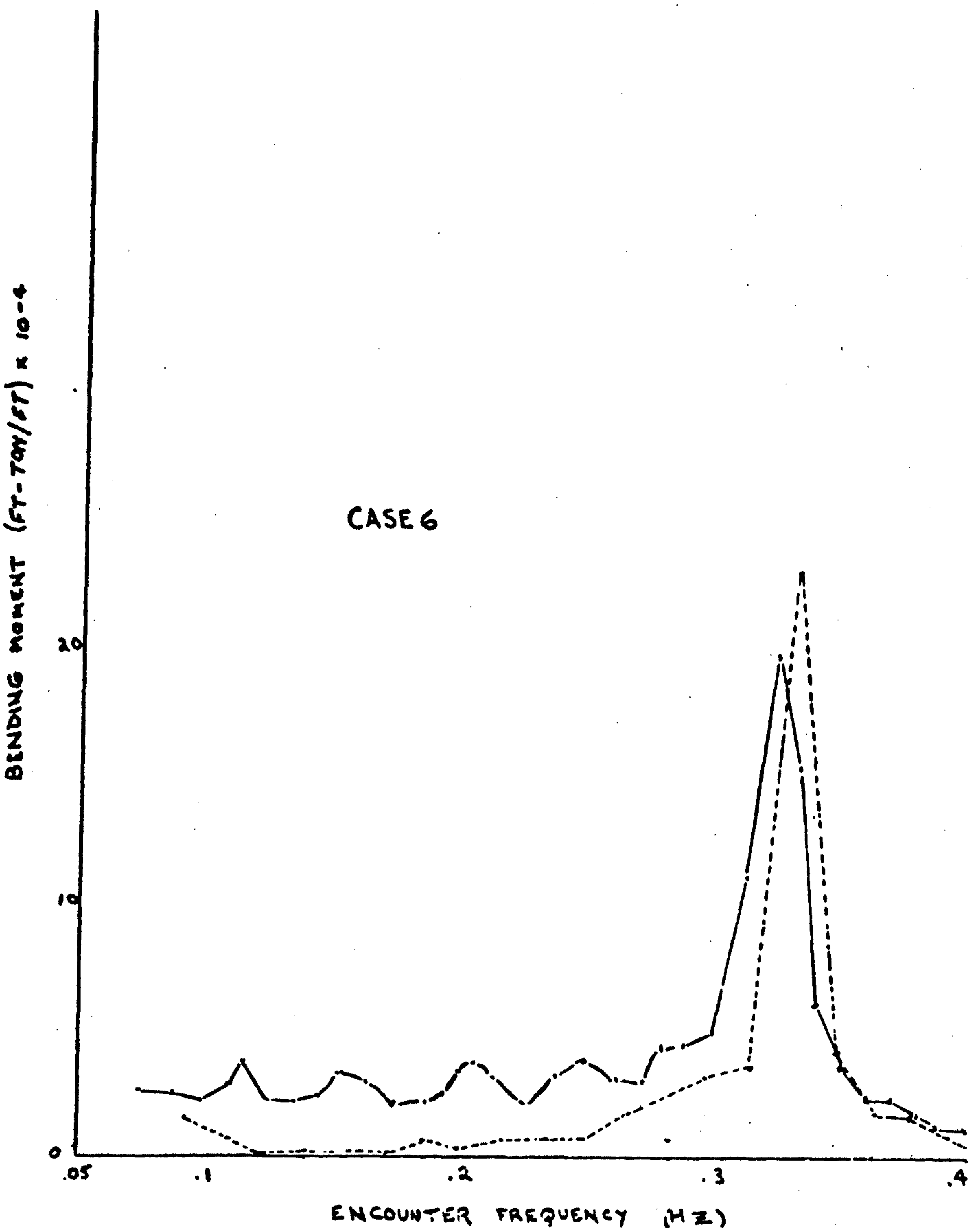

BENDING MOMENT (FT-TON/FT) x 10⁻⁴
40
30
20
10
0
CASE 2
.05
.1
.2
.3
.4
ENCOUNTER FREQUENCY (HZ)



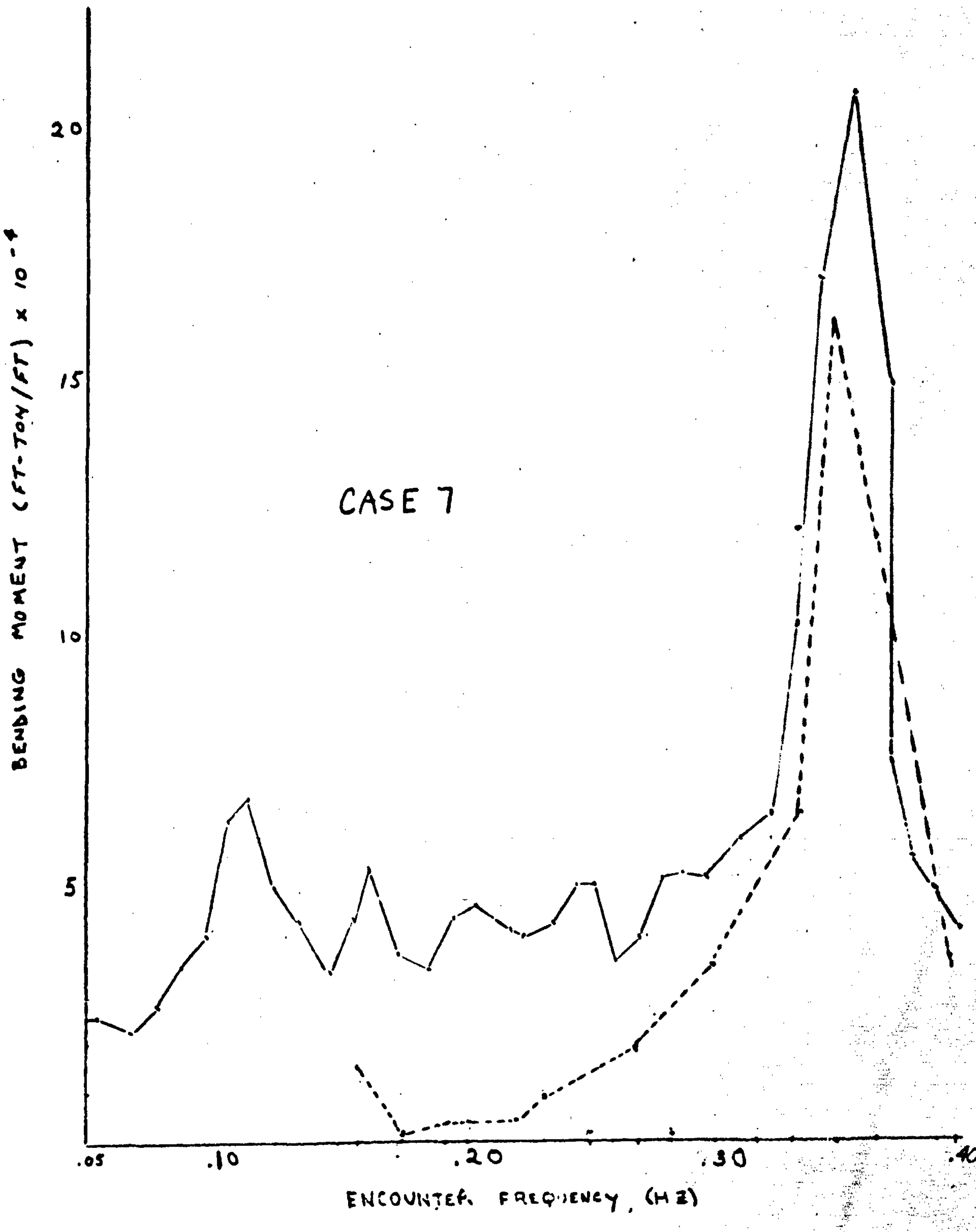
BENDING MOMENT (FT-TONS/FT) x 10^-4
40
30
20
10
0
CASE 3
.05
.1
.2
.3
.4
ENCOUNTER FREQUENCY (Hz)


40
30
20
10
0
BENDING MOMENT (FT-TONS/FT) x 10^{-4}
CASE 4
.05
.1
.2
.3
.4
ENCOUNTER FREQUENCY (Hz)

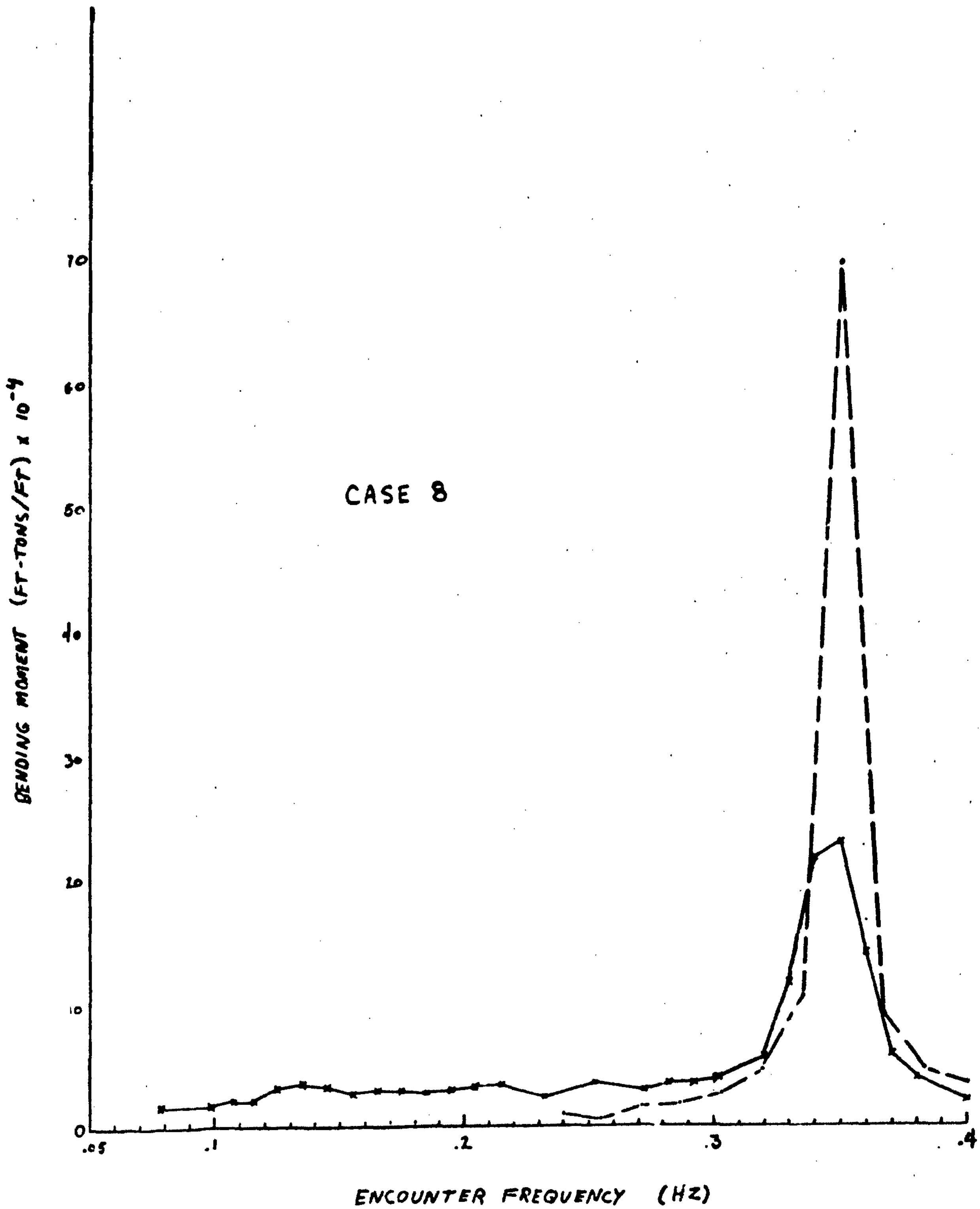

BENDING MOMENT (FT-TONS/FT) x 10^-4
40
30
20
10
0
CASE 5
.05
.1
.2
.3
.4
ENCOUNTER FREQUENCY (Hz)



CASE 6
BENDING MOMENT (FT-TON/FT) x 10-4
20
10
0
.05
.1
.2
.3
.4
ENCOUNTER FREQUENCY (HZ)



BENDING MOMENT (FT-TON/FT) x 10^-4
20
15
10
5
CASE 7
.05
.10
.20
.30
.40
ENCOUNTER FREQUENCY, (HZ)


CASE 8
BENDING MOMENT (FT-TONS/FT) x 10^-4
70
60
50
40
30
20
10
0
.05
.1
.2
.3
.4
ENCOUNTER FREQUENCY (HZ)

APPENDIX H

Det norske Veritas -- (Kare Lindemann)

"Calculation of Dynamic Vertical Bending
Moment for the Great Lakes Carrier
S. J. CORT"

DET NORSKE VERITAS
NORWAY

ADDRESS: VERITASVEIEN 1, HØVIK
POSTAL ADDRESS: P.O.Box 300, N-1322 HØVIK, OSLO, NORWAY
TELEPHONE: (02) 12 99 00/12 99 55
CABLE ADDRESS: VERITAS, OSLO
TELEX: 16192 VERIT N
BANKERS: DEN NORSKE CREDITBANK ACCOUNT NO. 7131.05.05700
FELLESBANKEN A/S, OSLO ACCOUNT NO. 8200.01.33654

Commandant (G-MMT-4/TP13)
U.S. Coast Guard
Washington, DC 20593

USA

YOUR REF.

OUR REF.
FDIV/KLin/EBE

DATE
29. January 1981

TECHNICAL REPRESENTATIVE/DTCG23-80-C-20007

Enclosed please find our final comments to the comparisons between computed and measured springing RAO's. As noted in the write up, we have by removing the aft transverse section from the analysis obtained a substantial change in the results. This change in modulation is justified since the linear theory applied does not account for sections inclined to the sea surface. Such sections has as noted a serious influence on the results which obviously tend to disturb the balance of forces.

We hope that you find cur comments of interest and if additional clearification is needed please let us know as soon as possible.

Yours faithfully
for Det norske Veritas

Kåre Lindemann

Kåre Lindemann
Senior Research Engineer

Ship Design
Branch
02 FEB 1981
(G-MMT-4/82)
Log. No. ________

U.S.C.G. Springing Project

Comments to comparisons:

The springing calculations performed by VERITAS were purely based on theoretical considerations, applying a new and advanced computer program, /1/.

However, this program which is linear can not account for transverse sections inclined to the sea surface. This was the case for the sections in the afterbody of "S.J. Cort". A redefined model of the hull without these aftermost sections gave more than 50% reduction of the peak bending moment and a slight increase in the resonance frequency, leading to a considerably better agreement with the measured data, (See enclosed figure).

It should further be noted that the amplification factor for bending moment near springing resonance change rapidly. Hence the calculations does not necessarily reveal the true behaviour of the response, unless a fine subdivision of the frequencies are chosen in this region. It may therefore be questioned whether or not the comparisons between different programs are representative, as long as the computations have been done for different frequencies, with unequal subdivisions, near resonance.

/1/ Skjørdal, S.O. and Faltinsen, O.M.:
A linear theory of springing.
Journal of Ship Research Vol. 24, No.2 June 1980 pp. 74-84.

S.J. CORT   COND. 1

DRAFT FWD = 19' 11"

DRAFT AFT = 22' 00"

SHIP SPEED = 12.5 KNOTS

TRANSFER FUNCTION - PEAK ANALYSIS

DYNAMIC VERTICAL BENDING MOMENT AMIDSHIPS

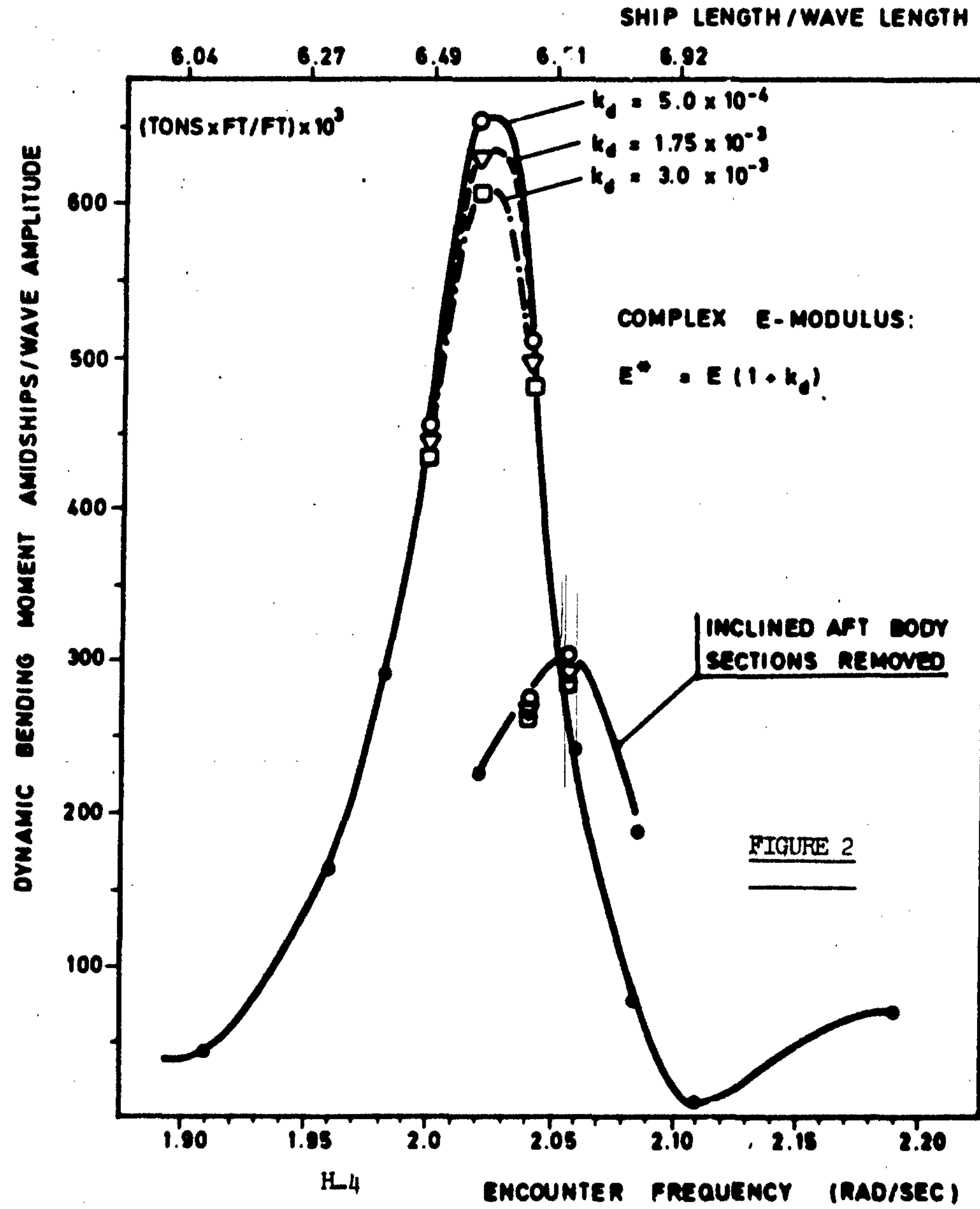


FIGURE 2

H-4

THEORETICAL EVALUATION

OF

SPRINGING IN SHIPS

TASK B.1: CALCULATION OF THE DYNAMIC VERTICAL BENDING MOMENT FOR THE "GREAT LAKES" CARRIER "S.J. CORT"

PRELIMINARY REPORT

27 August 1980

Bør/KLin/SB

CONTENT: PAGE:

1. INTRODUCTION

Theoretical calculations of the vertical dynamic bending moment amidships have been carried out for the Great Lakes carrier "S.J. CORT". Originally, the purpose was to perform these calculations for 8 different cases:

COND.	SPEED (MPH)*)	DRAUGHT			HEADING ANGLE (DEG.)
		FWD	MID	AFT	
1	14.4	19'11"	20' 7"	22'0"	6
2	14.4	19'11"	20' 7"	22'0"	11
3	14.7	27' 0"	27' 0"	27'0"	6
4	14.2	27' 0"	27' 0"	27'0"	9
5	13.5	27' 0"	27' 0"	27'0"	23
6	13.5	27' 0"	27' 0"	27'0"	10
7	11.6	18' 0"	19'11"	21'3"	0
8	11.6	19'11"	20' 7"	22'0"	20

TABLE 1

The bending moments were to be calculated for a frequency range 0.2 - 2.5 (rad/sec) with increments of 0.5 (rad/sec).

However, the actual computer program "NVSPRING" is based on the springing theory of Skjørdal and Faltinsen (ref. /1/), which is valid for head waves only. This eliminates the heading angle dependence in Table 1 and reduces the number of different conditions from 8 to 6:

*) We have interpreted the notation "MPH" as "English miles (1609 meters) per hour".

COND.	SPEED (MPH)	DRAUGHT		
		FWD	MID	AFT
1	14.4	19'11"	20' 7"	22'0"
3	14.7	27' 0"	27' 0"	27'0"
4	14.2	27' 0"	27' 0"	27'0"
5	13.5	27' 0"	27' 0"	27'0"
7	11.6	18' 0"	19'11"	21'3"
8	11.6	19'11"	20' 7"	22'0"

TABLE 2

Calculations for condition 1 revealed that a large number of frequencies was necessary to produce a meaningful RAO for the bending moment. Especially near resonance the program "NVSPRING" had to be run for small frequency steps in order to detect the resonance peak.

We therefore decided to concentrate the efforts on performing rather accurate calculations for condition 1. It is not expected that the other conditions will show any major discrepancies from these results, since the variations in speed and draught are rather small. However, we suggest that additional bending moment calculations near resonance may be performed for case 3, 5, and 8 on your request, when we have received some feed-back from the comparisons with measurements for condition 1.

2. COMMENTS ON THE THEORY

The theory behind the computer program "NVSPRING" is outlined in ref. /1/. However, some basic assumptions inherent in this theory should be emphasized:

1. The theory is linear, only valid for (infinitely) small oscillations. This is generally a good approximation in the high frequency region, since the wave-induced motions are small. However, the assumption may cause some problems for hull sections not intersecting the free surface normally.
   This is the case of the aftermost stations of "S.J. CORT", since the aft body sections are inclined to the still water line. These sections will contribute with a considerably amount of wave damping, even in the high frequency domain.

2. The theory is developed for regular, head waves only. However, for "nearly head waves" with a heading angle from 0^o to about 10^o the variations in the results are expected to be small.

3. The calculations of excitation forces are based on a "short wave" assumption. This may create some inaccuracies for waves longer than the shiplength.
   For springing calculations, however, the assumption is highly relevant. In fact, this theory is the most advanced springing theory developed today, since it is based on slender body methods to calculate the wave diffraction potential, rather than any strip theory or relative motion hypothesis.

4. The forced motion potentials have been calculated similarly to the Ogilvie and Tuck /2/ formulae. Added mass and damping in heave motion are evaluated by the use of a two-parameter Lewis-form technique.

5. The formulation includes a variable distribution of mass and stiffness along the hull beam. However, in the case of "S.J. CORT" a uniform weight and stiffness have been applied.

3. DAMPING

At resonance the peak will be determined by excitation forces and damping, since the mass forces and restoring forces will cancel. The damping in "NVSPRING" comes from two different sources:

1. Wave damping, due to formation of surface waves from the ship's forced motion in otherwise calm water.

2. Material damping in the steel structure. This structural damping is difficult to predict, since it is generally a function of several parameters, and it can only be measured experimentally. Skjørdal and Faltinsen have suggested that the structural damping could be included by introducing a linear Voight-type visco-elastic material by writing the Young's modulus on a complex form:

$$E^{*} = E(1 + k_d)$$

According to Lazan /3/ the actual range of k_d is:

$$5 \cdot 10^{-4} \leq k_d \leq 3 \cdot 10^{-3}$$

Our calculations have been carried out with three different values of k_d:

$$k_d = 5 \cdot 10^{-4}, \quad 1.75 \cdot 10^{-3}, \quad \text{and} \quad 3 \cdot 10^{-3}$$

The results in fig. 2 show no significant discrepancies between the bending moment curves drawn for the different choices of k_d. The model run by Skjørdal and Faltinsen, however, displayed a more significant dependence on k_d.

The reason is probably that the wave damping contribution in our case is the dominating part, due to the special aft body sections of "S.J. CORT" and the large beam/draught ratio

(about 5), while the model of Skjørdal and Faltinsen intersected the still water surface normally everywhere and had a smaller beam/draught ratio.

4. PRESENTATION OF RESULTS

The main data for "S.J. CORT" used in cond. 1 is:

Length	: L = 1000' (305 m)
Beam	: B = 104.5' (31.88 m)
Draught fwd.	: d_F = 19,11" (6.07 m)
" mid.	: d_m = 20'7" (6.27 m)
" aft	: d_A = 22'0" (6.70 m)
Displacement	: Δ = 56.608 L. Tons (55.717 metric tons)
Speed	: U = 14.4 MPH (12.5 knots = 6.45 mS^{-1})
Froude number	: F_n = 0.12
Second moment of inertia of midship section:	$I = 2.401 \cdot 10^6\ in^2ft^2$ (144.0 m^4)

The vertical dynamic bending moment as function of the encounter frequency is presented in the attached figures 1 and 2. Note that the moment is the sum of the wave bending moment and the springing moment and is given per wave amplitude. The unit is (L. Tons x FT)/FT x 10^3.

The wave bending moment is small at a frequency about 2 (rad/sec), so there will be a significant contribution from springing near this frequency.

3. REFERENCES

/1/ SKJØRDAL, S.O. and FALTINSEN, O.M.:
"A Linear Theory of Springing".
Journal of Ship Research, Vol. 24 No. 2,
June 1980, pp. 74-84.

/2/ OGILVIE, T.F. and TUCK, E.O.:
"A Rational Strip Theory of Ship Motion: Part 1".
Report No. 013.
Department of Naval Architecture and Marine
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The University of Michigan, Ann Arbor, Michigan,
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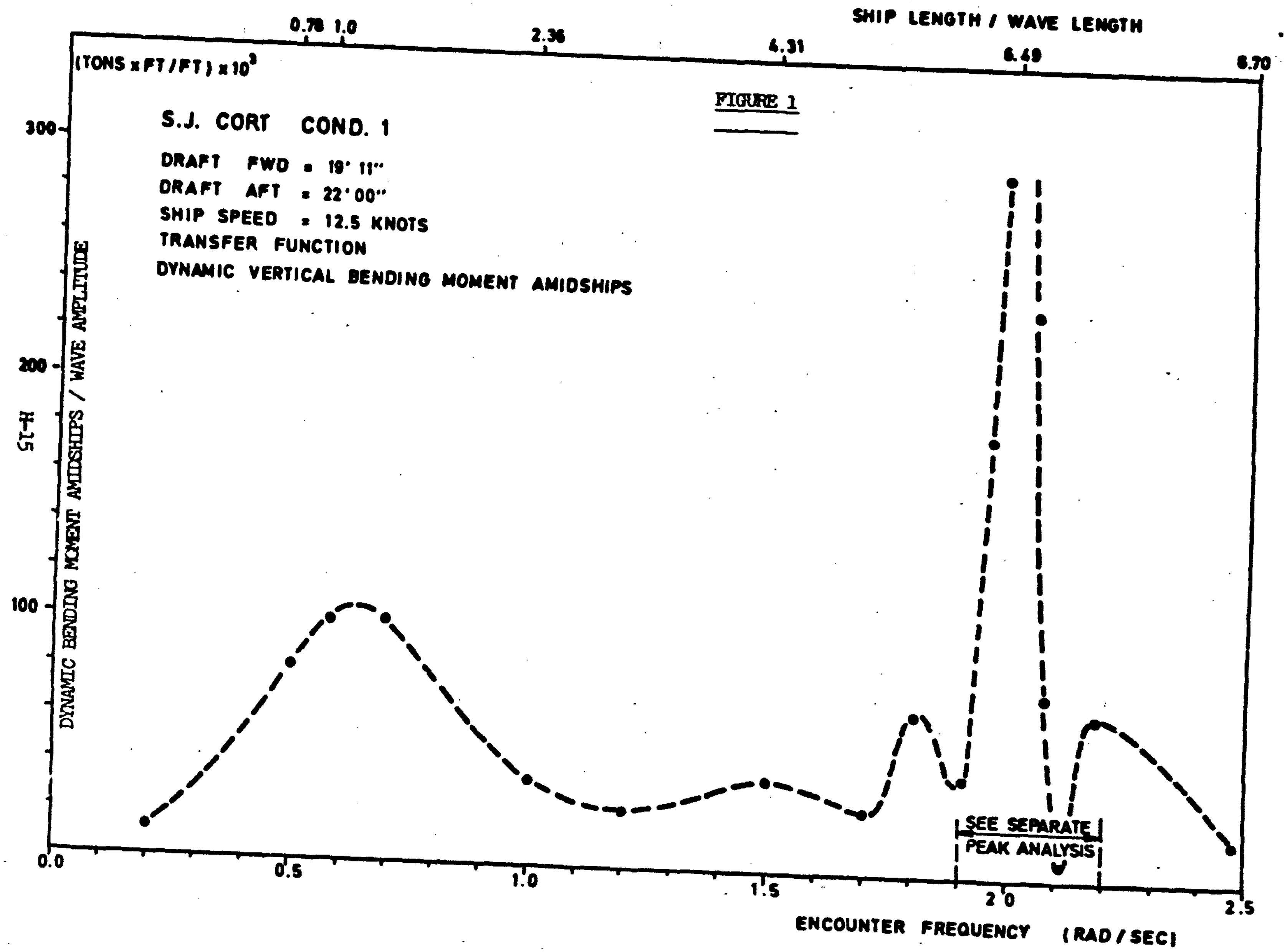
/3/ LAZAN, B.J.:
"Damping of Materials and Members in Structural
Mechanics".
Pergamon Press 1968.

FIGURE 1


SHIP LENGTH / WAVE LENGTH
0.78
1.0
2.36
4.31
6.49
8.70
(TONS x FT/FT) x 10³
S.J. CORT COND. 1
DRAFT FWD = 19' 11"
DRAFT AFT = 22' 00"
SHIP SPEED = 12.5 KNOTS
TRANSFER FUNCTION
DYNAMIC VERTICAL BENDING MOMENT AMIDSHIPS
DYNAMIC BENDING MOMENT AMIDSHIPS / WAVE AMPLITUDE
300
200
100
0.0
0.5
1.0
1.5
2.0
2.5
SEE SEPARATE
PEAK ANALYSIS
ENCOUNTER FREQUENCY (RAD / SEC)

S.J. CORT COND.1

DRAFT FWD = 19' 11"

DRAFT AFT = 22' 00"

SHIP SPEED = 12.5 KNOTS

TRANSFER FUNCTION - PEAK ANALYSIS

DYNAMIC VERTICAL BENDING MOMENT AMIDSHIPS

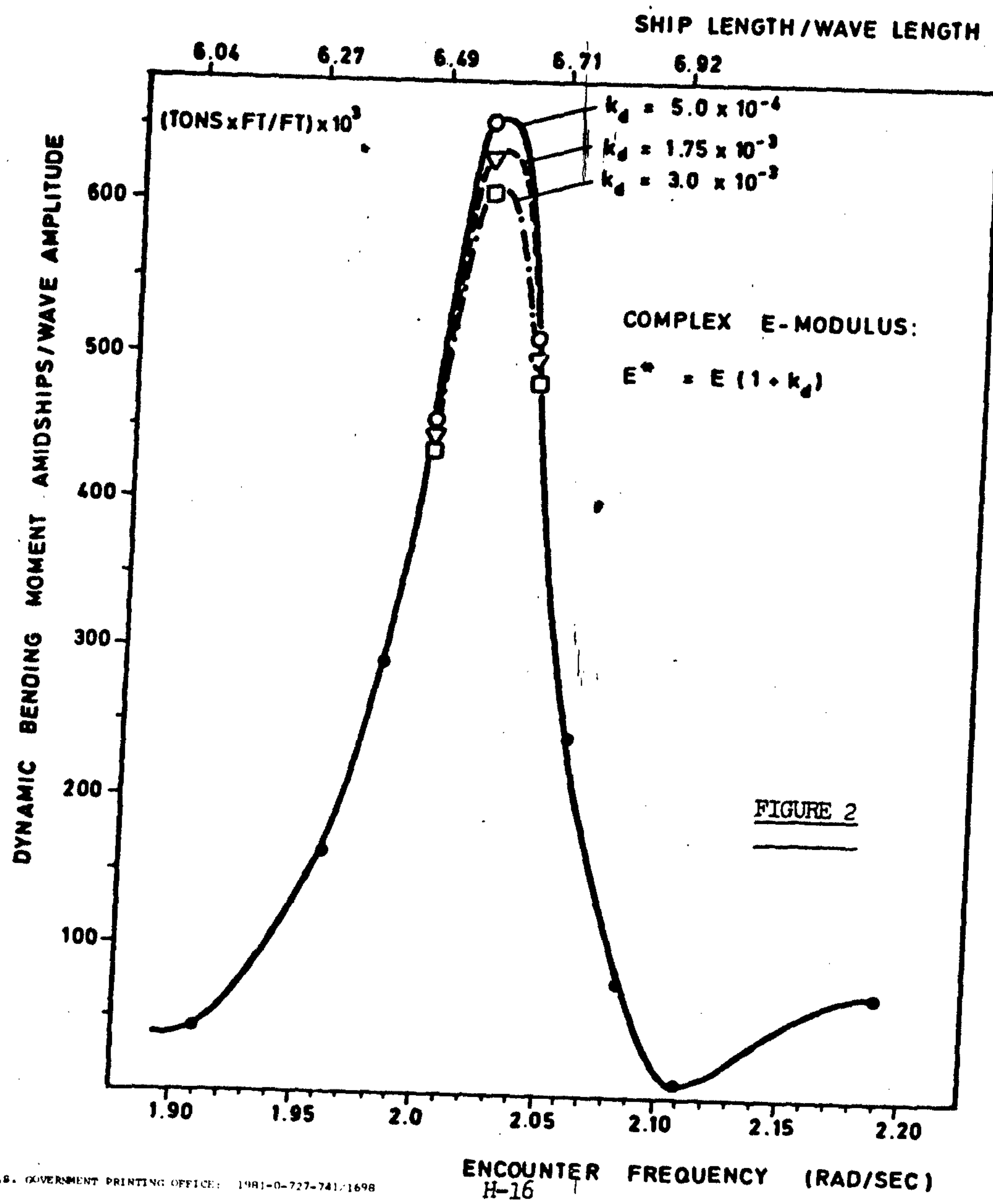


FIGURE 2

*U.S. GOVERNMENT PRINTING OFFICE: 1981-0-727-741/1698